

**Maintaining the Edge: How to Keep the U.S. Military Procurement System
Strong**

By

Charles Carroll

A thesis submitted to Johns Hopkins University in conformity with the requirements
for the degree of Master of Arts

Baltimore, Maryland
September 2018

© 2018 Charles Carroll
All Rights Reserved

Abstract:

The United States is facing a fiscal crisis at the same time it is facing a military crisis. The United States military needs to continue investing in future technologies and capabilities while also adapting to multiple new challenges and threats. The competing spending between federal programs makes all of this more complicated and the federal budget needs to be invested across a spectrum of critical areas. While an increase in military spending is needed, the question of how to effectively spend U.S. resources to remain on the most powerful military in the world needs to be re-examined. This thesis seeks to look back at historical examples to help chart a path ahead. The Department of Defense will need to show Congress it is making every effort to invest and modernize in a fiscally responsible manner, but this is not beyond the capabilities of the Department. The United States rose to military power in an era of similar constraints, but the adaptability and ingenuity of the American worker, soldier, sailor, airman, and marine allowed the U.S. to excel with new technology. Prior to World War Two, the United States faced massive deficits, economic downturn, unemployment, and a public skeptical about United States power projection. Policy makers and the military navigated through this to create the most powerful fighting forces in the world and the ingenious PAC-10 carrier strike group doctrine, which transformed the face of naval warfare.

Fast-forward into the future and the Department of Defense and the military branches have struggled in some cases to contain costs and provide the capability upgrades they seek for the warfighter. The Department focused very heavily on the ‘systems of systems’ concept in pursuit of a revolution in military affairs. The Joint

Tactical Radio System, which is covered in part two of this study, is a perfect example of these phenomena. In the end, the program did not create the results or war fighter capability that the program set out to create. On top of this, it cost a significant amount of time and money, just to require the Department to find an alternative solution in Iraq.

The Department also looked to make large investments in the 90s and 2000s into capital weapon systems to respond to forecasted need. The F/A-22 and the DDG-1000 were two examples of revolutionary acquisition that went off budget and off schedule. At the same time, the U.S. military also pursued successfully evolutionary acquisition and spiral development programs within the DDG-51 and the F/A-18E/F. The study concludes with a look at the how the Department should go about with future projects. Using the above weapons systems as examples, the study seeks to prove that evolutionary acquisition and spiral development needs to be considered to provide combat power and systems in quantities to meet the threat, but also provide the technological improvements the United States needs to stay dominant.

The dissertation/thesis is the culmination of the graduate degree. It represents an original critical or synthetic treatment of a subject in the student's field. It documents research formulated independently and presents its findings in a manner consistent with publications in scholarly journals or with scholarly books. The dissertation serves as a reference through the UMI (formerly University Microfilm, Inc.), Dissertation Abstracts International, and through publication in whole or in part. Manuscripts not conforming to the following standards will not be accepted as partial fulfillment towards the graduate degree.

Table of Contents

Introduction 1-12

Chapter 1: **Entering the Global Stage: Development of the Modern Navy** 12-29

Chapter 2: **Pursuit of Excellence: A Revolution in Military Affairs?** 29-46

Chapter 3: **Modern Acquisition and Cost Efficiencies** 46-69

Conclusion: **Making Sense of it all: How to Maintain the Edge?** 69-79

Introduction

The United States military and the national security community are at a crossroads. The security strategies and systems that supplied the armed forces that led the United States through the Cold War and into the 21st century are in need of alteration if the United States wants to enjoy same supremacy, or something similar. With the rapid expansion of technology and information systems in the 21st century, the landscape has changed, and adversaries are catching up to the United States. The barrier to entry for a lethal military is now lower, and regional adversaries and non-state actors are threatening the existing global structure. On top of these challenges, the U.S. faces mounting budget crises and competing political priorities that mean the military needs to invest in more cost effective solution. The U.S. military and policymakers need to pursue a strategy to incrementally improve combat systems and capabilities, rather than attempting to take large steps with new systems that in most cases spiral out of control in cost. While an increase in military spending is needed, the question of how to effectively spend U.S. resources to remain on the most powerful military in the world needs to be reexamined and we must remember how the U.S. innovated and rose to its position in the world.

To meet the threats of today, the United States needs to continue to increase its military budget. The Trump Administration, in its National Security Strategy, sees those challenges coming from Russia, China, Iran, North Korea, as well as from transnational threat groups like terrorist organizations or international crime organizations.¹ The Obama Administration also viewed the global threat matrix similarly.² This demonstrates

¹ The White House. "National Security of the United States of America. 2017

²The Obama Administration. "The National Security Strategy: 2015."

the nature and the longevity of the threat; it also exemplifies the complexity and range of the different type of capabilities and challenges the military needs to consider when planning to confront these different situations and threat actors. The U.S. military needs to be able to respond to great power threats, contain rogue and potentially nuclear states, and fight asymmetric wars all at potentially the same time. This requires varying skills, technology, and tactics that cannot be met by a one size fits all approach or system

These challenges require a military that is well equipped, supported, and flexible. A theme running through the National Security Strategies of both Obama and Trump Administrations is the need to restore our military capability. The United States spends a historically low amount on the military, both in percentage of federal spending and percentage of gross domestic product (GDP).³ To add to that, the military has sustained a high operations tempo that degraded equipment and troop readiness at high levels. The Department of Defense is consuming resources at a faster pace than anticipated and needs an injection of sustained capital investment to rebuild the worn down systems and repair the fatigue that the force has endured.⁴ In the next decade alone the U.S. military could face and over \$370 billion in deferred modernization alone, which will continue to put pressure on the budget.⁵ The U.S. can no longer take its qualitative edge for granted and will need to invest in future technologies if it is to operate against the current challenges of Russian, China, Iran, North Korea, and international terrorism, all which present a very

³The World Bank. "Military Expenditure (% of Central Government Expenditures)." The World Bank. https://data.worldbank.org/indicator/MS.MIL.XPND.ZS?locations=US&name_desc=true.

⁴ McCain, John. "Restoring American Power: Recommendation for the 2018-2022 Defense Budget." https://www.mccain.senate.gov/public/_cache/files/25bff0ec-481e-466a-843f-68ba5619e6d8/restoring-american-power-7.pdf.

⁵ Eaglen, Mackenzie. *Repair and Rebuild: Balancing New Military Spending for a Three-Theater Strategy*. Washington, DC: American Enterprise Institute, 2017.

diverse set of challenges.⁶ On top of needing to invest more, the United States Military needs targeted investment. The Department of Defense needs to work within the constraints of the current political and acquisition system. The Department cannot risk revolutionary jumps forward and focus on evolving its systems in a much less risky fashion.

Even though military spending is historically low as a percentage of the Gross Domestic Product, publically and intergovernmental held debt is historically high, with the U.S. Federal Reserve reporting it is hovering at 105 percent of GDP.⁷ This debt is not only a burden to future spending, but it is a direct threat to national security. At first glance spending can seem to be heavily favoring defense, and the discretionary budget does provide significant resources to defense, but that only tells one third of the story. U.S. debt is being driven not by military spending, or even other programs on the discretionary side of the budget, but by mandatory spending programs, which have very little Congressional oversight, and interest on the publically held debt, which are projected to increase rapidly over the next few years and exert more pressure on the budget.⁸

While the U.S. government does need to get its fiscal house in order, and nothing should be off the table, fiscal reform needs to be thoughtful. Most of the immediate harm that the military has endured from poor investment stems from the Budget Control Act of 2011, which was meant to be a legislative dead man switch never to be flipped. The law

⁶ Department of Defense. "2018 National Defense Strategy: Sharpening the American Military's Competitive Edge." 2018.

⁷ Desilver, Drew. "5 Facts about the National Debt." Pew Research 2018. <http://www.pewresearch.org/fact-tank/2017/08/17/5-facts-about-the-national-debt-what-you-should-know/>.

⁸ Congressional Budget Office. *The Budget and Economic Outlook: 2018 to 2028*. Washington, DC: Congressional Budget Office, 2018.

was passed by a bi-partisan coalition in 2011 as a response to mounting government debt and Congressional demands that a dollar for dollar but reduction accompany any new authorization for the United States to issue more debt. The Budget Control Act would implement harsh cross-governmental cuts called sequestration. The Budget Control Act contained a delayed onset, which would allow for a super committee to meet and discuss how to implement bipartisan changes to spending. The super committee was unable to come up with an agreement and government spending was on track to experience sequestration. In 2013, when the Budget Control Act was enacted and sequestration took effect, the Department of Defense was faced with making across the board cuts to all accounts rather than targeted reforms⁹. This resulted in uncontrolled damage across the department resulting from cancelled purchase contracts to delayed training exercises.¹⁰ Fast forward to the current period and Congress has passed budget deals to increase the amount of money allowed before sequestration takes effect, but it is still not enough to repair the harmful effects that the Department has endured.

This study seeks to consider the current defense needs of the United States within this budget context and realities of the tasks at hand. While spending reform is needed, the United States cannot approach the military budget with a reductionist mindset. The Department of Defense needs to proactively and quickly move to implement spending reforms so it can procure and maintain the best equipment at the best prices, all while maintaining the ingenuity that propelled the U.S. military to its place of prominence. The

⁹ Harrison, Todd. "What has the Budget Control Act of 2011 Meant for Defense?" Center for Strategic and International Studies 2018. <https://www.csis.org/analysis/what-has-budget-control-act-2011-meant-defense>.

¹⁰ McCain, John. "Resorting American Power: Recommendation for the 2018-2022 Defense Budget." https://www.mccain.senate.gov/public/_cache/files/25bff0ec-481e-466a-843f-68ba5619e6d8/restoring-american-power-7.pdf.

Department has a history riddled with case studies of cost overruns, off schedule projects, and unmet expectations that leave critical capabilities out of the U.S. policymakers' playbook. The Department also has a rich history of innovation that allowed it to make do with the resources it had at the time and propelled it beyond its competitors and enemies. This is not assignment of blame for the Department of Defense, maintaining a strong lead over near-peer competitors requires innovation and more importantly funding. In this fiscal and political environment, the United States needs to work to get the most out of its dollar. The first part looks at innovation in the inter-war and World War Two eras. The United States was facing similar conditions, coming off large government spending programs, a skeptical political culture, and a tight fiscal house. Military planners, strategists, and advanced industry were able to build the PAC-10 fast attack carrier strategy that helped lead to victory in the Pacific.

The U.S. military, in the early twentieth century, differed greatly from the institution we see today. Taking into account the differences in societal structure and technology, the U.S. military also was supported by a different economy and economic capacity. With the industrial revolution producing huge gains in technical achievement and manufacturing, a new era of weaponry and tactics was about to emerge and transform the U.S. military. The military was not built to be an expeditionary force projecting power across two oceans, but ingenuity and calculated risks helped transform it.

Aircraft carriers and naval aviation proved to be the new, advanced concept that most heavily industrialized nations wanted to exploit. While the British harnessed the technology first, the political climate and budgetary situation by imperial ambitions and the Great War meant the nation never was able to take advantage of carrier aviation. The

United States harnessed this technology to build a strong and innovative capability and incorporate these technologies into naval strategy. The United States was able to do this in part because of the strong industrial base, and also because of sound development of naval doctrine and incremental increasing of capabilities. The first two fast attack carriers began as cruisers, but had to be converted to meet treaty obligations. The U.S. Navy figured how to use this non-traditional technology, incrementally upgraded its capabilities, and introduced the fast attack carrier doctrine, all within a short time span. Targeted investment in technological advances turned out one of the most formidable naval formation in history, and secured the United States' position as the most capable and powerful military of the 20th century. The political support for the program also served as a major boost. Unlike in Britain, where service competition took valuable resources away from naval aviation, the U.S. Military did not allow inter-service competition to get in the way of the progress the same way that the British did, although there was a healthy amount. Policymakers and Congress supported this with targeted legislation, specifically appropriations, but not to the same levels as we see today. This all played a crucial role, and proves to be a significant difference between today's environment and then. Services are now competing heavily for a choked off funding stream, and unlike in the 1930s and 40s, the threat is much more intangible. At the dawn of World War Two, leaders could rely on their constituencies noticing a threat in Europe, or at least a change in geopolitical tensions. Although the United States had a healthy camp of supporters who wanted to maintain neutrality from any conflict, there was at least a threat that the public could grasp. Now, the United States faces multiple threat vectors from very heterogeneous enemies. One set of tools will not be able to handle all

the threats, and it is hard to make the argument that more is needed. Nevertheless, the U.S. experience in World War Two, which arguably made the U.S. Navy the most powerful in the world, and secured the position for a generation, provides a cautionary tale about what could happen if policy makers allow service infighting, such as what happened in the British military and over ambitious projects drown out innovative and incremental developments.

That point aside, the United States still needs to harness this ingenuity as it moves into the 21st century, but it needs to do so in a fiscally responsible manner. The lesson learned from U.S. naval aviation in the Second World War should be a lesson to military planners. The Department of Defense needs to focus on acquisitions that are technically achievable as well. The second part of the study looks into the issue of what makes systems technically achievable and what happens when the United States pursues revolutionary technology that is beyond the scope of possibility. Industry developing weaponry for the Defense Department is overburdening the process with requirements ending in unfeasible systems, such as the Joint Tactical Radio System's Ground Mobile Radio. The second part focuses solely on this system for the reason that it shows that over-zealous requirements can lead to waste and failed acquisitions. In the case of Joint Tactical Radio System, there was a technological achievement as it helped introduce the concept of software defined radios across a broad spectrum of military applications, but specifically the program broke under its own weight and never fully fielded due to cost overruns and lack of technical achievements. Moreover, the U.S. military pursued a revolution in military affairs aggressively as the thinking was that a modernized and interconnected force would rule the 21st century. While the thought process and doctrine

was sound, pushing the technological envelope to realize gain created political and fiscal issues that hamstrung modernization efforts. The U.S, at the beginning of the 21st century, seemed fixated on achieving a revolution in military affairs, and at any cost. While it would be unfair to say that the pursuit of this technical evolution did not yield results, it did consume a large amount of time and resources. The U.S. Military did see a significant change in the way it absorbed battlefield data and communicated, but more generally the U.S. can look back at a score of failed programs, in addition to Joint Tactical Radio System, that point to overspending for little results in some cases.

Finally, the U.S. military and policy makers should look at proven development and acquisition techniques for use in the future. Evolutionary acquisition and spiral development prove cost effective and introduce new and needed technology while removing the risk from the procurement system. This third part looks at some of the largest programs of recent and compares them to some of the older, successful legacy systems in the active arsenal. These comparisons are meant to stoke discussion and cannot be truly evaluated on an even scale, as the military developed the platforms to meet different requirements. What these examples do have in common is both the Air Force and the Navy saw them as bringing combat capabilities into the modern era and create a strong backbone of a future force. This study looks F-22, F/A – 18, DDG-1000 class of ships, and DDG -51 class of ships. The study seeks to prove that by slowly upgrading legacy systems. In this case the DDG-51 and F/A -18, which are legacy systems, combat power is brought online in a less risky fashion and saves the taxpayer money. Juxtaposed, the cutting edge technology in the F-22 and DDG-1000 proved incredible capability, but cost overruns and technical challenges limited the system buys

and the small quantities procured did not fulfill the intended requirement. The Department of Defense must decide how to approach technology in the most cost effective manner. That means the Department of Defense needs to look at it developing new technologies or building and evolving on old system to adapt with new technology. The U.S. military is currently working with older legacy systems and adapting them to the new fight, in lieu of brand new equipment because of the political fights that have embroiled federal spending in the last few years. Looking into the future acquisition programs, there needs to be a healthy mix of new cutting edge systems, but these cutting edge systems sometimes put the services at a capability loss when the programs do not produce the needed quantities to fill the requirement, meaning the burden falls on older technology to make up the shortfall.

Military technology is inherently different and with the changing nature of technology there is no true way to compare apples to apples. Comparing Joint Tactical Radio System, the DDG-1000, DDG-51, F-18, and F-22 leaves a lot of room for debate and challenge as each of these systems was imagined for differing roles, needs to deal with differing combat stresses, and operate with completely differing systems and technology. Ideally the arguments would be apples to apples comparison. Comparing this technology, and the acquisition strategy of pre-Cold War military and even pre-volunteer military also creates its own unique sets of challenges as the population that troops are drawn from is completely different and other limiting factors. This study also does not take into account the role of Congress in the life of procurement process. Budget gimmicks, the Budget Control Act, and Continuing Resolutions provide an unstable and uncertain future for these programs and the services in general. The military, coming off

multiple wars, has provided for the nation above and beyond their calling and has worked very resourcefully as of recent to invest and focus on warfighter needs and readiness. Coupled with a more conservative and incremental approach to rebuilding and refreshing the arsenal that they depend on is necessary to continue its path into the 21st century. If the points in this study are not taken into account, the Department will see its purchasing power take a significant hit as the U.S. moves farther into the 21st century.

To be fair, the idea of military reform as a way to rein in military spending is not new in recent politics. Congress, the Executive branch, and academia have been trying to tackle this issue for years. One can trace the modern acquisition reform effort to the 1960s and Robert McNamara's reform process that brought the Department the well-known Planning, Programing, and Budget process. He saw this process as a way to quantify what the Department actually needed, and put acquisition in a mindset that didn't just focus on procurement, but the full life of the system and put the Office of the Secretary of Defense in charge of the process.¹¹ Fast-forward to the 1980s, Congress begins to seriously look at the defense spending and acquisition reform again with the creation of the Military Reform Caucus and the Packard Commission.¹² Just as Sen. Gary Hart (D-CO) questioned if an increase in military spending would result in a safer America in the 1980s, President Trump is facing the same questions.¹³

Congress is also taking another deeper look at how to bring the defense procurement system into the 21st century. The Section 809 panel was created in the fiscal year 2016 National Defense Authorization Act. This panel, which is made up various

¹¹ Grimes, Steven R. *PPBS to PPBE: A Process Or Principles?* Army War College, Carlisle Barracks: Defense Technical Information Center, 2008

¹² Hart, Gary. "An Agenda for More Military Reform." *The New York Times*, May 13, 1986.

¹³ Daniel Wirls, "Congress and the Politics of Military Reform," *Armed Forces & Society* 17 1991: 487-512

subject matter experts and leaders in the field, is Congress's reaction to yet another binge of concern about procurement cost and flexibility. The interim report focuses on big areas of concern, such as acquisition adaptability, complexity in the acquisition process, complex workplace regulations, and a changing industrial base.¹⁴ These are all needed changes, but like the attempts before the Panel, the recommendations will not stick unless the Department of Defense decides to make these changes. The Department has a history of success in overcoming massive technical hurdles to create the best qualitative force in the world today, but it also has a past littered with missteps. All the recommendations that the Section 809 panel is putting forward are correct. The Department of Defense should make it easier for business to work with it, the workforce does need reform, procurement needs to be less complex and more intuitive, but until mindsets change at the program levels, risky projects could still end up over budget and under producing. The following provides some of those changes, which need to part of the conversation if the Department of Defense and Congress want to control defense spending while keeping the qualitative edge it enjoys.

Finally, although this study looks at the how to change the system to continue to equip the force with the best materials and weaponry, one capability that is not addressed by the study but is vitally important to the success of the U.S. military in the past and into the future is training and manpower. The United States military is made up of 5 different branches with five distinct cultures. The United States Army, Navy, Marines, Air Force, and Coast Guard all serve the U.S. in distinct fashions. The study addresses a small facet of military culture differences as it effects acquisition in its study of the Joint Tactical Radio System and the United States Marine Corps solution for a joint communications

¹⁴ *Section 809 Panel Interim Report*. Washington, DC: Section 809 Panel, 2017.

platform. The five service branches all serve to specialize in certain aspects of the mission to defend the United States, and with this comes differences in training, culture, and equipment needs. It is important that in any strategy moving forward, the United States Government and policy makers take into account the differences between service branches in future acquisitions¹⁵. Policy makers and leaders have even battled over the importance of training the force we have over increasing funding for manpower and weaponry acquisition. Army Chief of Staff General Mark Milley has even made the argument that it is critically important to increase readiness before increasing the size of the Army, because without ready troops to deploy, even the best strategy will not be effective. This study does not take this into account and is in no means a signal to ignore the critical debate in personnel in training, but serves to focus on the role of systems acquisitions.¹⁶

Chapter 1

Entering the Global Stage: Development of the Modern Navy

World War Two saw the world's approach to military strategy and technology change. Many have looked at World War Two as a significant turning point for how war was fought. Victor Davis Hanson, in his book, *Carnage and Culture*, Hanson examines the marquis battle of Midway, which was one of the largest aircraft carriers on carrier naval battle in history. He saw the ingenuity of the U.S. warfighter, and the use of carrier technology as a distinct mark of western dominance. Innovative command and

¹⁵ "Understanding Military Culture." Department of Veterans Affairs. https://www.mentalhealth.va.gov/communityproviders/military_culture.asp.

¹⁶ Dickstein, Corey. "Army: Increasing Combat Readiness More Important than Increasing Force Size." *Stars and Stripes*, June 7, 2017, 2017, sec. News.

individualism in tactical thinking marked the unique power that the U.S. brought to the field.¹⁷ Because of innovation like this, the U.S. fighting force transformation in World War Two is important to understand the U.S. transformation to its current military status. The U.S. was emerging from a significant economic downturn, faced depressed military budgets and a bridled military capacity because of international treaty obligations, and the U.S. political worldview was far more isolationist than it is today.

Even with these challenges, World War Two saw a significant maturation and widespread use of carrier aviation in all theaters. The Japanese used carrier aviation to great effect at the beginning of the conflict, most notably in the attack on the U.S. Army and Navy bases in Pearl Harbor, Hawaii. Hanson argues that the Japanese had some of the most powerful and well-defended carriers of the time, but they did not make a dominant navy like the carrier did to the U.S. Navy. The U.S. made significant use of carrier based aviation in the Atlantic and Pacific theaters, but most notably restructured the fleet around projection capabilities based in carrier aviation, and away from the traditional structure of concentrated firepower anchored by large capital ships. No longer was it necessary for opposing fleets to close within firing range, but they now had the ability to engage from blue water positions, in far beyond visual range battles. The U.S. was able to effectively harness and use carrier aviation, helping to pave the way to U.S. military dominance for decades.

How did this happen? What did the United States do to restructure the fleet around carriers, and create such numerical advantages that these forces had resiliency in the face of an advanced enemy, like the Japanese. Even more, allies who had mastered

¹⁷ Victor Davis Hanson, *Carnage and Culture: Landmark Battles in the Rise of Western Culture* (New York: Anchor, 2003)

the technology, like the British, who invented the concept of the carrier, fell behind the U.S. One of the advantages the United States had on the rest of the participants in the war was a huge economy, which the government was attempting to mobilize in the wake of the great depression. The U. S. industrial base gave policy makers the tools to build a large navy. This coupled with the strategic considerations of the U.S. and the need to mobilize a large workforce made a strategic retooling and expansion of the U.S. Navy achievable and led to the ascent of the force to the top position in terms of global strength. More importantly, the U.S. Navy was able to adapt strategy effectively to meet the unique challenges of a global conflict. The Navy also was able to work with industry effectively to build and evolve capability.

Naval Context prior to World War 2

The United States Navy was built for major action and decisive engagement in the interwar period. With the aircraft carrier was in its infancy, the Navy's primary focus was on firepower. Battle groups were built around large battleship formations, which could meet the enemy in a broadside assault. The idea would be to concentrate firepower from large capital ships to make the sum of the assault fatal to the composition of enemy fleet therefore rendering their firepower lost. Warplanes focused on "Major Tactics,"¹⁸ or the use of large fleet maneuvers to achieve objectives. The U.S. Navy planned specifically for a contingency in the Pacific, and created Plan Orange to prepare for war against Japan. This plan initially focused on large battle groups moving slowly across the Pacific achieving tactical objectives and being supplied by a long and potentially vulnerable logistics trains. Smaller surface combatants, trained in night search tactics, would seek

¹⁸ Trent Hone, "U.S. Navy Surface Battle Doctrine and Victory in the Pacific," *Naval War College Review* 62 (2009): 67-105.

out the enemy and prepare the opposing fleet for combat by inflicting damage prior to the staged battle. Aircraft carriers, an infant class of ship, would provide air cover for the main battle fleet, the logistics train, and aid in spotting the enemy. The main offensive tool, which required smaller surface combatants to protect, was the battleship.¹⁹

The five party treaties and subsequent modification significantly affected the composition of the major naval powers' fleets until nullification. The initial agreement imposed strict numerical and tonnage restrictions on the Navies of France, Britain, Italy, the United States, and Japan in an effort to deescalate some of the tensions in the Pacific. Specifically, a 5-5-3 ratio governed the tonnage of American, British, and Japanese warships respectively.²⁰ Pundits of the time saw this treaty as severely limiting for the United States, and allowed for advancement in shipbuilding outside of the U.S. Most fleets focused on heavy cruisers and speedier combatants to fill out their navy, while the U.S. had to cut back on certain innovations in naval architecture to comply with the treaty, especially the 5-5-3 rule, which dictated powers do not build a numerical advantage in ships.²¹ Naval powers did build aircraft carriers, but primary sources indicate there was much more of a focus on surface combatants.²²

Japan, Britain, and the United States led the pack in naval innovation. Britain was an established naval power; Japan was an enthusiastic observer in World War One, looking to build on the countries naval power proved earlier in the century; and the U.S. was grappling with an increasing role in the international security faced challenges.

¹⁹ Hone, Trent. "U.S. Navy Surface Battle Doctrine and Victory in the Pacific." *Naval War College Review* 62, no. 1 (Winter2009, 2009): 67-105.

²⁰ Five Power Naval Treaty of 1922-1923." *Five Power Naval Treaty of 1922-1923* (01/11, 2009): 1.

²¹ Ferraby, H. C. "EUROPE BUILDS NAVIES; EXPERT SAYS U.S. LAGS." *Chicago Daily Tribune* (1923-1963), Feb 07, 1927.

²² Committee on Naval Affairs. United State House of Representatives. *List of Combatant Ships Not Limited by Washington Treaty*, 1928.

Britain's Navy had challenges modernizing because of budgetary battles and institutional challenges. The Royal Navy, in 1918 had an established air corps that had been on the leading edge of aviation, incorporating land based bombers to fight against opposing ships and theorizing about the use of aircraft carrying ships, but lost significant headway due to budgetary issues and restructuring.²³ The Royal Air Force (RAF), which was newly established after the First World War, absorbed all of the Royal Navy's airmen. To build on this complication, the defense budgets were severely cut in the inter-war period, starving the services of needed modernization resources.²⁴ General H.M. Trenchard, who was the head of the RAF and the Chief of the Air Staff, protected the infant RAF from budget and encroachment threats. His arguments convinced policymakers that the RAF should be the sole authority to design, build, and procure aircraft. He blocked both the Army and Navy's efforts to take air assets from the service, and argued in favor of larger budgets for defense of the British Isle and not on imperial power projection, which carrier aviation embodied due to its expeditionary nature.²⁵ This led to the Royal Navy only being able to focus on traditional combatant development, rather than innovation in tactics and doctrine. Starved of necessary financial resources and political backing, the Royal Navy developed traditional capabilities, and did not innovate.²⁶ The Royal Navy also did not exploit gains. There was no true study of modern carrier aviation, and the carriers that the Royal Navy used focused on fleet defense and not projection. This can

²³ Hone, Thomas C. and Mark D. Mandeles. "Interwar Innovation in Three Navies: U.S. Navy, Royal Navy, Imperial Japanese Navy." *Naval War College Review* 40, no. 2 (03/01, 1987): 63.

²⁴ Ibid., 63

²⁵ Ibid., 63

²⁶ Ibid., 63

also be partially attributed to the lack of control over plane design, limiting the Royal Navy to no specialized aircraft.²⁷

The Japanese focused on developing and innovating carrier aviation. The Imperial Japanese Navy (IJN) successfully used aviation assets in 1914, launched off of converted cargo ships, to destroy a German outpost, and quickly understood the benefits and significance of this capability. The IJN worked with the British to westernize their air arm, subsidized industry research, and institutionalized education to develop strategy and tactics. The IJN followed the common theme of using carriers to defend fleets and reduce combat power of the enemy fleet through localized attacks, rather than spear assaults and project strike capability. To be clear, through a distinct campaign to educate, innovate, and fund carrier aviation, the IJN and Japan were able to build a strong service and capability.²⁸

U.S. Ship Building Before the War

The capacity for U.S. shipbuilding played a vital role in the massive increase in the U.S. Navy's combat power in the Second World War. The specialized shipyards needed to build a sophisticated Navy were not available in large numbers to the U.S. prior to the war. The U.S. had around 12 industrial shipyards active prior to the war.²⁹ At its height, the U.S. shipbuilding industry during the war employed around two million direct and indirect employees to build a large and capable fleet. To achieve this, there was a rapid expansion of yard capacity and labor.³⁰

²⁷ Ibid., 63

²⁸ Ibid., 63

²⁹ Heinrich, Thomas B. "Jack of all Trades: Cramp Shipbuilding, Mixed Production, and the Limits of Flexible Specialization in American Warship Construction, 1940-1945." *Enterprise & Society* (Oxford University Press / USA) 11, no. 2 (06/01, 2010): 275.

³⁰ Ibid., 275

This was not a new challenge to the United States. In World War One, the German Navy took a toll on allied shipping and there was an attempt by the U.S. to surge to build merchant and troop carrying ships to supply the Triple Entente in the war effort. While this never came to fruition because the war ended before these contracts could be delivered upon, the U.S. had experience in ramping up shipbuilding in response to a global conflict.³¹

Industry in the United States had the necessary tools, but did not have the volume to meet such an increased need for ships. Most naval construction in the United States focused on building less complex ships such as barges and small cargo craft, and did not focus on the complex builds of ocean going steamships. The British naval industry was far and beyond the leader in advanced shipbuilding in the 1800s. In the late 1800s, the U.S. shipyards began retooling due to an increased demand for passenger ships and also an increase in spending from the U.S. government on naval power. Larger shipyards focused on adapting their production line to “Flexible Specialization,”³² meaning they invested in advanced machinery and skilled labor that could be put to the task building ships and integrating complex systems into the designs of new merchant and passenger ships. This laid the foundation for being able to expand capacity to build much more advanced ship designs like destroyers, carriers, and other advanced ships, yet this capacity was still low at the eve of World War Two. This is mainly due to the fact the U.S. economy did not depend on a strong merchant fleet, as the British still maintained

³¹ Klein, Maury. *A Call to Arms : Mobilizing America for World War II*. (New York: Bloomsbury Press,) 2013.

³² Heinrich, Thomas B. "Jack of all Trades: Cramp Shipbuilding, Mixed Production, and the Limits of Flexible Specialization in American Warship Construction, 1940-1945." *Enterprise & Society (Oxford University Press / USA)* 11, no. 2 (06/01, 2010): 275.

the largest fleet at this time.³³ The Washington Treaty also added to the woes of U.S. shipbuilding in the Inter-war period. Because the U.S. was unable, due to obligation, to construct warships larger than 10,000 tons, the big yards were forced to compete for the limited work, building at most heavy cruisers. This led to a closure of a few yards and the dispersal of the industrial base work force. Companies like Cramp & Sons struggled for work and closed their doors. This was of particular issue for the development of the industry, since this company had begun working in shipbuilding when wood was the predominate material, transitioned to iron, and then led in steel construction.³⁴ New York Shipbuilding, Bethlehem Steel, and Newport News also tried to survive the desperate economic situation by creating an illegal cartel over bidding to syphon work to one another.³⁵

The U.S. Navy and Congress scrambled to increase shipbuilding capacity when war seemed inevitable. This buildup was further reinforced by the U.S. Congress passage of the Two Ocean Navy Act, which authorized massive increases in the naval arsenal.³⁶ As U.S. Navy strategy dictated, a large fleet was needed quickly. Industry needed to rapidly expand and new shipyards opened up. These new shipyards, mainly managed by inexperienced staff and upper level management struggled to enter into the complex world of naval shipbuilding. Larger warships required significantly more complex building and engineering processes, and yards needed to be experienced in armor, electronics, fire control, and weaponry to build successful vessels. The newer companies could not necessarily provide these skills. In contrast the more advanced

³³ Ibid., 275

³⁴ Ibid., 275

³⁵ Ibid., 275

³⁶ Ibid., 275

shipyards could provide services and specialize in many different types of ships. Newport News focused on building aircraft carriers, for example, leaving other ships to be dealt with by other shipyards. New York Shipyard, an experienced builder of heavy surface combatants, was able to adapt due to investments in flexible specialization. The first orders of the war, cruisers were able to change to carriers because engineering and labor could adapt and rework designs while still using the materials and tooling available.³⁷ Industry's flexibility in designing larger ships was helpful at the beginning, but excess capacity was needed in all types of shipbuilding. Heavy cruisers could take up to three years to construct, longer for bigger ships so construction slots were in high demand.³⁸ The more green shipyards, which had capacity to build more than just simple cargo carriers, relied on mass production and batch construction methods to speed up production time.³⁹

Moreover, the economy and politics favored massive investment into heavy industries even prior to the war. Facing down the Great Depression, massive government spending seemed to be the only solution out of the crisis. Industry was brought to a quick pace because of infrastructure projects. Concrete, steel, and other heavy manufacturing processes were needed to fulfill commitments for the Tennessee Valley Authority, the Conservation Corps, and others.⁴⁰ Labor unions played a big role in the Administration's calculus at the time. When implementing major projects President Franklin Roosevelt worked to coopt labor into supporting his agenda. The American Federation of Laborers

³⁷ Ibid., 275

³⁸ Klein, Maury. *A Call to Arms : Mobilizing America for World War II*. (New York: Bloomsbury Press,) 2013.

³⁹ Heinrich, Thomas B. "Jack of all Trades: Cramp Shipbuilding, Mixed Production, and the Limits of Flexible Specialization in American Warship Construction, 1940-1945." *Enterprise & Society (Oxford University Press / USA)* 11, no. 2 (06/01, 2010): 275.

⁴⁰ Duncan, Thomas K. 1. and Christopher J. Coyne "The Origins of the Permanent War Economy." *Independent Review* 18, no. 2 (Fall 2013, 2013): 219-240.

(AFL), a large labor organization was especially vital to appease, as it had large and skilled membership.⁴¹ In 1932 the AFL proposed to support the maximum expenditure possible under naval treaty obligations at their national convention. The resolution, sponsored by the machinists unions did not pass, but it did help to set organized labor's sights to shipbuilding as a source of government funded work. The AFL came out in support of a \$300 million authorization to build Navy ships the next year.⁴² Labor helped to push for construction of new ships much more than industry did in the years before the war. The American body politic still had a sour taste in its mouth from World War One. The Congress had acted against these industrial players, who the public perceived as a reason for U.S. involvement in the First World War, by passing legislation curbing their profits in future defense programs.⁴³ This simple fact made organized labor's support of shipbuilding that more important.

Two shipyards were vital in the creation and heavy manufacturing of aircraft carriers. Both Newport News and New York Shipbuilding, companies that had experience in building complex platforms, helped to fulfill the need for aircraft carriers. The New York Shipbuilding Company (NYS) opened its doors in the late 1800s and focused on building heavy ships. The company began building for the U.S. Navy in 1906, with a contract for cruisers. Focusing on heavy machining and advanced manufacturing techniques, the company was able deliver ahead of schedule for its first government ship, solidifying its participation in U.S. Navy ship building.⁴⁴ NYS then moved on to building capital ships for the U.S. Navy. During the Great War, NYS provided torpedo boats and

⁴¹ Ibid., 219-40.

⁴² Ibid., 219-40.

⁴³ Ibid., 219-40.

⁴⁴ "New York Ship Building." Globalsecurity.org. Accessed July 2017, 2017.

some merchant shipping capacity. Post Great War, NYS was tasked with building cruisers for the United States Navy. The Saratoga class cruiser, a planned fast attack heavy cruiser was then ordered to be converted into a fast attack carrier to comply with the tonnage limits under the Washington Treaty.⁴⁵

The Depression affected NYS as well. Lack of work and poor leadership led to the unions taking control of the yard and pressuring Washington to provide more work. This all changed when the U.S. Navy, in preparation for World War Two, started to lean on yards to revamp and rebuild. With the sharp increase in demand, the NYS shipyard alone employed 35,000 people and made a variety of surface combatants.⁴⁶ The US Navy also relied on NYS to again change a cruiser design into a carrier. Because of its success with the previous conversion with the Saratoga Class cruisers in the 1920s, the US Navy commissioned the yard to build the Independence Class light carrier. This aircraft carrier again was built on the frame of a cruiser that the Navy forwent for more carrier capacity.

Newport News also played a significant role in building aircraft carriers for the United States Navy. In 1933, Newport News was the first American Shipyard to be launch a purpose built aircraft carrier.⁴⁷ The USS Ranger was the U.S. Navy's first attempt to launch a real carrier. Newport News was then contracted in 1938 to build the Enterprise, Hornet, and Yorktown, of the Yorktown Class of aircraft carriers. These carriers made it to the fleet and join in the Battle of Midway, where the U.S. was able to seize the initiative of the war. The Company made further progress when they launched the Essex Class of carriers. The Newport News Shipyard built the first few of this class.⁴⁸

⁴⁵ Ibid.

⁴⁶ Ibid

⁴⁷ Huntington Ingalls. "NNS and the American Aircraft Carrier." Accessed August 2017, 2017.

⁴⁸ Ibid

Aircraft Carriers in the U.S. War Effort

The United States entered the war with a limited navy. The 5-5-3 agreements from the Washington Treaty dictated smaller ship builds. The U.S. built its first carrier in 1922, but utilized converted ships rather than purpose building carriers. These ships mainly to provide for fleet reconnaissance and fire control.⁴⁹ The first aircraft carriers launched scout aircraft.⁵⁰ These aircraft carriers were developed under the constraints of the Washington Treaty and came in at under 20,000 tons, relatively small.⁵¹

The U.S. Navy had to innovate to get to the position it was in the late stages of the war. As previously mentioned, the U.S. had no specific built carrier meant for decisive battle or fast attack concept as it was not developed at the time of the first carrier orders. The Navy used the pre-World War Two concept of the carriers providing protection and spotting. The carrier was brought to the forefront after the U.S. fleet of heavy battleships was heavily damaged in the attack on Pearl Harbor. The small fleet of carriers available to Navy leadership was used to directly respond to the Japanese attack, starting with launching a raid on Tokyo itself. This is not to say that battleships and heavy cruisers were irrelevant after Pearl Harbor, as shipyards continued to produce them into the war.⁵² Doctrine existed that placed the carrier in an air superiority role, but still in defensive type nature. Over the next few years of the conflict and as dictated by need, the carrier evolved as the Navy experimented with innovative techniques. By 1945 the U.S. aircraft carrier was filling in rolls covering amphibious operation, hunting and destroying the fleet, and escorting shipping. The carrier and Naval leadership was able to use after

⁴⁹ Tillman, Barrett. "Forging the Weapon." *Naval History* 24, no. 5 (10/01, 2010): 14.

⁵⁰ Rubel, Robert C. "The Future of Aircraft Carriers." *Naval War College Review* 64, no. 4 (09, 2011): 12-27.

⁵¹ Cressman, Robert J. "Historic Fleets." *Naval History* 23, no. 1 (02, 2009): 12-13.

⁵² "New York Ship Building." *Globalsecurity.org*. Accessed July 2017, 2017

action reviews and innovative doctrine and war gaming to create a lethal and flexible force.⁵³

Specifically up until 1943, carrier doctrine was similar to that of the battleship. They were used for ambush, reconnaissance, and amphibious support. They also played a critical role in protection of bases and fleets. The plans were to keep them grouped tightly, for ease of defense, and usually leave them within range of friendly airfields and battle groups to layer their protection. This presented problems for the Navy as it limited the carriers' mobility and hampered their effectiveness against the opposing fleets. In 1942, leaders realized that doctrine needed to change to allow carriers to operate more freely and change to a sound and specific doctrine governing the implementation of carriers. Admiral Chester Nimitz and his team were able to begin experimenting with new roles for carriers when the light Independence Class carriers, built by the New York Shipbuilding,⁵⁴ and some of the larger class carriers like the Essex, Yorktown, and, Lexington came online, which were built by Newport News⁵⁵. These new ships integrated new technologies and management methods to make the most out of new technology. Aircraft had identify friend or foe (IFF) technology moving into this time as well. With the new air search, surface search, and ship to plane communications suites, the air wings and carriers were much more effective at directing and interdicting on threats and targets.⁵⁶

⁵³ Hone, Thomas. "Replacing Battleships with Aircraft Carriers in the Pacific in World War Two." *Naval War College Review* (2013).

⁵⁴ "New York Ship Building." Globalsecurity.org. Accessed July 2017, 2017.

⁵⁵ Huntington Ingalls. "NNS and the American Aircraft Carrier." Accessed August 2017, 2017.

⁵⁶ Hone, Thomas. "Replacing Battleships with Aircraft Carriers in the Pacific in World War Two." *Naval War College Review* (2013).

This new technology, coupled with some of the Navy's best minds, allowed for experimentation in new techniques and formations. At the same time, escort ships experimented with new ways to screen aircraft carriers from enemy submarines. What developed was a new doctrine for a mobile carrier task force, reliant on speed, to attack the enemy. Known as PAC-10, the fast attack concept of using Essex class carriers and Independence class carriers in groups of four made up by two types each.⁵⁷ The Independence Class carriers would provide fleet protection while the Essex class carriers would provide strike packages. The new air and surface search radars would also allow for night operations. PAC-10 provided for a common operation doctrine, desperately needed for the carrier forces, and the speed of the group allowed for quick strikes, which off put the Japanese, who were beginning to sustain operation-disrupting casualties in the fleet. Through 1944, the fleet capitalized on opportunities like the battle at Wake Island and other fights to test and refine the battle doctrine, working technological issues out and streamlining procedures. The Independence class carriers also refined their Combat Air Patrol capability to provide expert coverage and air superiority over the fleet during all types of operations. The operation tempo and effectiveness of the fast attack fleets increased and the lethality of these forces and groups. The industrial base was also able to provide the fleet with a significant influx of equipment and ships to support the growing fleet. This coupled with the effectiveness of the doctrine created a combine naval combat power that was revolutionary in use of naval air and surface assets.⁵⁸ Specifically up until 1943, carrier doctrine was similar to that of the battleship. They were used for ambush, reconnaissance, and amphibious support. They also played a critical role in protection of

⁵⁷ Ibid.

⁵⁸ Ibid.

bases and fleets. The plans were to keep them grouped tightly, for ease of defense, and usually leave them within range of friendly airfields and battle groups to layer their protection. This presented problems for the Navy as it limited the carrier's mobility and hampered their effectiveness against the opposing fleets. In 1942, leaders realized that doctrine needed to change to allow carriers to operate more freely and change to a sound and specific doctrine governing the implementation of carriers. Admiral Chester Nimitz and his team were able to begin experimenting with new roles for carriers when the light Independence Class carriers, built by the New York Shipbuilding,⁵⁹ and some of the larger class carriers like the Essex, Yorktown, and, Lexington came online, which were built by Newport News¹. These new ships integrated new technologies and management methods to make the most out of new technology. Aircraft had identify friend or foe (IFF) technology moving into this time as well. With the new air search, surface search, and ship to plane communications suites, the air wings and carriers were much more effective at directing and interdicting on threats and targets.⁶⁰

This new technology, coupled with some of the Navy's best minds, allowed for experimentation in new techniques and formations. At the same time, escort ships experimented with new ways to screen aircraft carriers from enemy submarines. What developed was a new doctrine for a mobile carrier task force, reliant on speed, to attack the enemy. Known as PAC-10, the fast attack concept of using Essex class carriers and Independence class carriers in groups of four made up by two types each.¹ The Independence Class carriers would provided fleet protection while the Essex class carriers would provide strike packages. The new air and surface search radars would also

⁵⁹ "New York Ship Building." Globalsecurity.org. Accessed July 2017, 2017.

⁶⁰ Hone, Thomas. "Replacing Battleships with Aircraft Carriers in the Pacific in World War Two." *Naval War College Review* (2013).

allow for night operations. PAC-10 provided for a common operation doctrine, desperately needed for the carrier forces, and the speed of the group allowed for quick strikes, which off put the Japanese, who were beginning to sustain operation-disrupting casualties in the fleet. Through 1944, the fleet used opportunities like the battle at Wake Island and other fights to test and refine the battle doctrine, working technological issues out and streamlining procedures. The independence class carriers also refined their combat air patrol capability to provide fleet air coverage to allow for the Essex Class air wings to operate strike packages more efficiently. The use of sensor suites, communications equipment, and state of the art aviation equipment enabled the fighter and bomber aircraft to operate with a lower issue rate as well.⁶¹

Policy and Strategy

An increase in the United States Navy was generally supported as war drew closer, but, even before the need for wartime increases, the U.S. political and security dialogue was focused on the weak state of the United State Navy. President Roosevelt, who was an Under Secretary of the Navy under President Woodrow Wilson,⁶² took office in 1932 and shortly after began acting on recommendations from the U.S. Navy issued recommendations to significantly increase the number of surface combatants deployed by the Navy. Shortly after this report was issued, the Congress appropriated monies to build destroyers, carriers, and other surface combatants. This money was part of a larger omnibus package aimed at revitalizing industry and providing jobs, but started industry working on Naval assets.⁶³ Congress was also a driver of this increase. The Trammel-

⁶¹ Hone, Thomas. "Replacing Battleships with Aircraft Carriers in the Pacific in World War Two." *Naval War College Review* (2013).

⁶² "Ship Building 1933-1945 - Franklin D. Roosevelt." GlobalSecurity.Org July 2017.

⁶³ Ibid.

Vinson Act authorized ship building in the Navy to replace old ships and build the U.S. Navy to full strength. At the time, the U.S. had restrictions on what it could build and the tonnage of ships, but the U.S. did not even build up to this limit; the Act changed that and authorized a build to the level, although it did not fund it.⁶⁴ Actual appropriations to build ships of the fleet would come in separate appropriations.⁶⁵ The authorization provided the Navy and Congress extreme flexibility in increasing the size of the Navy. As the threat of war continued to grow, the Congress passed the Naval Expansion Act of 1938, which authorized an across the board 20 percent increase in U.S. Navy combat power.⁶⁶ The shipbuilding strategy was continued with the passage and signing of the Two-Ocean Navy Act, which authorized a 70 percent increase in Navy Combat power in 1940. Of larger significance, this act finally gave the U.S. Navy truly offensive capabilities. In testimony before the Naval Affairs Committee, Chief of Naval Operations Admiral Harold Stark submitted a plan, which would drastically increase the offensive capability of the surface fleet, and included 18 aircraft carriers.⁶⁷

How did the carrier affect U.S. Navy doctrine, and why so successful?

The aircraft carrier was a new weapon in the arsenal of the modern navy and World War Two was the proving ground. Navies had success with the carrier in World War One and had built and war gamed with them enough to understand their potential in combat but that view was limited. The Japanese were able to innovate with carriers and launch a successful carrier raid that almost crippled the U.S. fleet, but they were not able

⁶⁴ Ibid

⁶⁵ Naval History and Heritage Command, Communications and Heritage Command. 2014. As war in Europe escalated, 1940 expansion act came when platforms mattered most. *The Sextant*(July 19, 2014).

⁶⁶"Ship Building 1933-1945 - Franklin D. Roosevelt." GlobalSecurity.Org July 2017.

⁶⁷ Naval History and Heritage Command, Communications and Heritage Command. "As War in Europe Escalated, 1940 Expansion Act came when Platforms mattered most." *The Sextant* (July 19, 2014.).

to sustain the program. The British, who were leaders in naval aviation during the Great War, did not continue the trend and did not place a priority on expanding naval aviation as the political discourse in the interwar period saw it as inherently colonial and expansionary, therefore not a cogent use of money. The island nation also faced a political game between services and a diversion of resources from building naval aviation capability, instead focusing on

Through necessity, innovation, and capacity, the United States was able to experiment with the aircraft carrier to make the most innovative solution and strategy to employ the weapon. Evidenced by the political and industrial support for naval expansion and shipbuilding, the U.S. Navy's ambition to best employ the aircraft carrier was supported by the U.S. Although it may seem that the aircraft carrier was an expensive project that shipyards pushed for to increase revenue, but with the volume of ships being produced and the drastic need for the U.S. Navy to bolster existing and open new yards to increase capacity, the evidence does not point to industrial and political design. The narrative of the aircraft carrier and the U.S. Navy is one of innovation and adaptation. Industry and Congress may have had a significant part in making it possible, but the U.S. Navy evolved a cogent strategy and doctrine to make use of the advanced weapon systems that the industrial base, expanded by the service, made possible.

Chapter 2

Pursuit of Excellence: A Revolution in Military Affairs?

Moving to today and more generally the post-Cold War era, the U.S. is facing a unique but not unseen challenge posed by changing international economics,

technological capacity, and availability of information. Technology is changing at a rapid pace and bringing new concepts and tactics into the realm of possibility. The environment has many similarities to the early twentieth century in this regard, just as explained in the previous section. Other international allies and adversaries are figuring out how to use and integrate this technology into their tactics, strategy, and overall geopolitical strategy. The main difference is that the United States is entering this period at the top of the spectrum, in terms of power. Similar to the United Kingdom in the early twentieth century, the United States faces multiple threats to its technological primacy and must efficiently move into the future to maintain the edge.

The United States is facing the proliferation of commercial technology to adversaries, a resurgent class of near-peer competitors, asymmetric threats, rogue states, and historically lower defense budgets. Yet, it appears, in certain criteria, the U.S. military continues to hamstring itself by pursuing revolutionary changes in doctrine and technology, often at too fast a pace. Looking at the early 2000s, it is clear the U.S. military was affected by the Revolution in Military Affairs (RMA), as laid out by Joint Vision 2010. The biggest question about the RMA is, did it bring about effective change or did it make the U.S. pursue technologies that did not produce the benefits expected? The Joint Tactical Radio System provides a strong case study, which exemplifies a larger trend of programs that cost significant investment but did not perform as intended. The Joint Tactical Radio System program intended to launch the U.S. military into the 21st century battlefield with new capabilities and technology to allow for the revision of doctrine. The data throughout points RMA that brought the U.S. military added technology, especially when it came to networked capabilities, but the Joint Tactical

Radio System study shows that the military is best served by slowly and incrementally approaching these changes. Slow and steady change is a risk adverse way of identifying the solution, and in this fiscal and security environment, the U.S. military needs to maintain an aversion to unnecessary development risk. Although certain aspects of the Joint Tactical Radio System survived, the process to create the all-in-one radio proved to diminish precious time and resources, with the services needing to adapt as conflict arose and development failures mounted. The U.S. needs to approach these large technical leaps with caution, but it is necessary to push the boundaries of technology to achieve change.

The Information Battlefield

In March of 2003, U.S. forces were racing through Iraq. Small and agile, these forces brought a high degree of technical power to communicate and coordinated with one another, maintain full situational awareness, and collect and disseminate valuable intelligence on the enemy's movements and activities. This tech heavy force entered Iraq being able to track all of their units through the newly introduced blue force tracker and other new, unproven technology. Their convoys were supposed to maintain connectivity to their commanders sitting in the military command posts, and the individual soldier would be empowered to email and text other troops across the battlefield. This concept grew out of changes to the military concepts, tactics, and strategy after failures to communicate and maneuver in the first gulf war, and a reorganization of the military started during the demise of the Soviet Union.⁶⁸ These new systems were well practiced on paper, but caused issue with U.S. troops who took them to war.⁶⁹

⁶⁸ Talbot, David. "How Technology Failed in Iraq." *MIT Technology Review* (2004).

⁶⁹ Ibid.

The U.S. military was undergoing a massive change in the character of its institutions and operations at the close of the Cold War. Through the change of the security environment, lessons learned, and the geo-political landscape, the U.S. military understood it needed to continue to evolve into a joint, coordinated force. The Department of Defense commissioned studies to see how the U.S. would fight under this construct as well. In 1994 and 1995 Johns Hopkins Advanced Physics Laboratory sponsored the Joint Warfare Requirements Study at the request of the Department of Defense, to examine the viability of the Joint Concept.⁷⁰ The concept of Joint Operations first appeared in 1986, with the Department of Defense's reorganization under Goldwater-Nichols, which emphasized reduction of redundancy and operational streamlining.

Throughout the last two decades, controversy has swirled around the U.S. use of military force in Iraq and Afghanistan and the impact of the Rumsfeld doctrine on the success of U.S. operations. In 2002 Donald Rumsfeld wrote an article, "Transforming the Military," which was published in *Foreign Affairs* and laid out his Rumsfeld Doctrine. Secretary Rumsfeld argues that a revolution in military technology and strategy will allow for the U.S. to operate with a smaller footprint and improved lethality.⁷¹ His article largely reinforced the Bush Administration's belief that warfare was evolving into an environment that requires small footprints of highly networked troops, which would act as a force multiplier. The Bush Administration adamantly believed this was the way to

⁷⁰ Manthorpe, William. "The Emerging Joint System of Systems: A Systems Engineering Challenge and Opportunity for APL." *Johns Hopkins APL Technical Digest* 17.3 (1996).

⁷¹ Rumsfeld, Donald H. "Transforming the Military." *Foreign Affairs* 81.3 (2002): 20.

propel the U.S. security apparatus into the 21st century, and made it an important part of the campaign.⁷²

Rumsfeld's vision was not revolutionary. The Department of Defense was undergoing a repurposing after the fall of the Soviet Union and needed to reorganize around lessons learned in the first Gulf War, where the inability to re-task and effectively maintain constant communication affected the speed of the advance into Iraq and destruction of Iraqi forces in Kuwait. The idea for the network centric warfare developed from a notion of multiple systems working together. In Admiral William Owens' piece *The Emerging U.S. Systems of Systems*, the Vice Chairman explains how the U.S. military is experienced in three fundamental changes, which he calls revolutions. He posits the U.S. military is moving forward due to the collapse of the Soviet Union and the emergence of the unipolar world, the shrinking defense budgets, and a RMA.⁷³ To Admiral Owens, the coming revolution will bring upon huge advances in military sensing, communications, and application of force. These systems of systems will allow the U.S. military to enjoy situational-awareness unencumbered by the fog of war and lack of communication.⁷⁴

Joint Vision 2010

Joint Vision 2010 is a strategic document that mapped out the route for the armed forces and the United States security apparatus post-Cold War. The threat and geo-political environment was changing, and the U.S. military leaders needed to plan for the emergence of asymmetric threats and rogue nations, which would threaten the world

⁷² Shachtman, Noah. "How Technology almost Lost the War: In Iraq the Critical Networks are Social- Not Electronic." *Wired Magazine* 11.27.07.

⁷³ Owens, ADM William. "The Emerging U.S. System-of-Systems." *Strategic Forum: Institute for National Strategic Studies* 63 (1996).

⁷⁴ Ibid.

order.⁷⁵ U.S. military leaders, and the Joint Chiefs of Staff envisioned these threats, and saw six core concepts needed to combat and maintain the global order. Joint Vision 2010 saw the need for all services of the military to work together in a joint fashion and achieve “full spectrum dominance”⁷⁶ on the battlefield of the 21st century. The six core concepts, or “critical elements”⁷⁷ the U.S. military were to pursue the joint operating concept were people, leadership, doctrine, education, training, organizational structure, and material.⁷⁸ The Joint Vision assessed the viabilities, challenges, and achievements of each of these categories, but overall the Joint Vision pushed for what people within the Department of Defense referred to as network-centric warfare. The U.S. military, in a joint capacity, would use technology to focus communications, logistics, and force protection to a level never seen before.⁷⁹ The Joint Vision 2010 document was seen as a necessary part to avoid a major conflict in the future and to maintain U.S. dominance in a uni-polar world. Military thinkers saw the times pointing to a Revolution in Military Affairs (RMA) that the U.S. needed to realize, or fade into obscurity. Thinkers posed this period as pivotal as the change in technology change, which lead to the carnage of the Great War. The U.S. stood the chance to fall to a new power if it did not meet and exceed the threat environment, which was developing after the Cold War.⁸⁰

Revolutions in Military Affairs (RMA)

⁷⁵ "Operationalizing Joint Vision 2010[*]." *Airpower Journal* 12.3 (1998): 102. Print.

⁷⁶ The Joint Chiefs of Staff. *The Joint Vision 2010*. Ed. John Shalikashvili. U.S. Department of Defense, 2000.

⁷⁷ Ibid.

⁷⁸ Ibid.

⁷⁹ Ibid

⁸⁰ "Operationalizing Joint Vision 2010." *Airpower Journal* 12.3 (1998): 102.

One of the key tenets pushing the idea that the Department of Defense needed to reform was the idea that the 21st century was ushering in a revolution in military affairs (RMA). With the increase in technology and advances in consumer products and communications, military leaders sought to take advantage of the changes and create a new concept for the U.S. Armed Forces.

Many authors have investigated the idea of the RMA in the post-Cold War era.. Andrew Marshall, the Director of the Office of Net Assessment in the Department of Defense gives a useful definition of RMA for this paper's purpose. He posited that an RMA is "a major change in the nature of warfare brought about by the innovative application of new technologies which, combined with dramatic changes in military doctrine and organizational and operational concepts, fundamentally alters the character and conduct of military operations."⁸¹ The theory behind RMA as defined by Prezelj, Kopac, Zibera, Kolak, and Grizold in their piece "Evolutionary Reality in Revolution in Military Affairs: Results of a Comparative Study" is "Discontinuous, radical, non-incremental, and even disruptive change"⁸² to military technology, doctrine, and strategy. These scholars argue that RMA is not necessarily a quick and disjointed change, but has more of an evolutionary process to the change. The authors of the study studied dozens of militaries that sought to reformat in the 1990s and found that fewer than ten percent of them actually experienced revolutionary change in the five-year study period.⁸³

Their piece brings up a split in the school of thought that tries to explain how militaries modernize and adapt to the new battlefield. On one side there is the idea that

⁸¹ Gongora, Thierry, and Harald von Riekhoff, eds. *Toward A Revolution in Military Affairs*. (Westport, CT: Greenwood Press,) 2000.1

⁸² Prezelj, Iztok, et al. "Evolutionary Reality of the Revolution in Military Affairs: Results of a Comparative Study." *Romanian Journal of Political Science* 15.2 (2015): 4-34..

⁸³ Ibid.

militaries evolve to changing circumstances, such as the theory laid forward in “Evolutionary Reality in Revolution in Military Affairs: Results of a Comparative Study.” The authors took a comparative look at many militaries, focusing on Eastern European militaries emerging from the Cold War. They examined 33 countries that attempted to grapple with modernizing their military for a modern security environment, and only found that a mere 2% of the countries armed forces studies were able to achieve revolutionary change, and of that small percentage, only a small amount of revolutionary change was achieved. They argue overall that most change is achieved through natural evolution, and is a smoother transition than the fractious revolutions in doctrine that revolutionary thinkers see as normal.⁸⁴

Teodor Frunzeti explains in his article, “Content and Dynamics of the Current Revolution in Military Affairs,” how RMAs differ from military revolutions, as RMAs are specifically focused changes on the military balance in regions and with military. He views changes in military technology such as the invention of gunpowder as fundamental military revolutions as they altered the geopolitical landscape of great power conflicts and how societies work. He believes that, over the course of the 20th and 21st centuries, there have been multiple RMAs resulting in the change in respective regions military balances.⁸⁵

Ofer Fridman takes a different tact in defining RMAs. In his piece “Revolutions in Military Affairs that did not occur,” he examines how RMAs come about. Fridman cites the trend of literature explaining the phenomena of RMAs. Ofer Fridman sees that

⁸⁴ Prezelj, Iztok, et al. "Evolutionary Reality of the Revolution in Military Affairs: Results of a Comparative Study." *Romanian Journal of Political Science* 15.2 (2015): 4-34.

⁸⁵ Frunzeti, Teodor. "Content and Dynamics of the Current Revolution in Military Affairs." *Strategic Impact* 49.4 (2013): 7-12.

RMAs, while not always successful, are a combination of political, technological, and military developments, which come together to form a change of how country's military's do business. Fridman sees these transformations as a slow moving evolutionary process. Through case studies, he proves how militaries move slowly through the correct circumstances.⁸⁶

Retired Army officer Douglas C. Lovelace, Jr, in his piece titled, "The Evolution in Military Affairs: Shaping the Future U.S. Armed Forces," dives into the specifics of a RMA versus an Evolution in Military Affairs and examines the U.S. military as it resets for the post-cold war era. Through the use of qualitative and quantitative evidence, Lovelace argues, the U.S. military adapts to new security challenges through evolution, not revolution. Specifically, Lovelace sees an evolution as allowing for small changes to respond to the transient nature of the post cold war security environment.⁸⁷

A critical area missing in this research is how the pursuit of this revolution helped or hurt the U.S. military's ability to advance into a new doctrine to meet new security threats. In a political environment marred by stagnation and gridlock, and a budget uncertainty that harms the U.S. services, how has the reorganization helped or hurt? Did technological research help to propel the services forward to reach the potential of an RMA or just distract from critical linear evolutions in military science and technology.?

How do you benchmark RMA progress? It's not a singularly agreed upon method, as noted in the literature above, but technological development and how it affected the course of conflict is common denominator. This paper will critically examine

⁸⁶ Fridman, Ofer. "Revolutions in Military Affairs that did Not Occur: A Framework for Analysis." *Comparative Strategy* 35.5 (2016): 388. Print.

⁸⁷ Douglas C. Lovelace, Jr. "The Evolution in Military Affairs: Shaping the Future U.S. Armed Forces " *Strategic Studies Institute* (1997)Print.

whether the Joint Tactical Radio System helped to advance future concepts of networked war, or if the Joint Tactical Radio System delayed critical fielding of evolutionary military technology. The paper will seek to examine scholarly works, acquisition documents, and government oversight reports, and contextually appropriate media reports with the objective to create a picture of how the program progressed, what went wrong, how it responded to warfighter needs, and, after the program was changed or restructured, if any of the technology or aspects of the program survived in future acquisition programs. The programs were Army led, but stood to change the doctrine of the entire U.S. military and represented an attempt to break weapon and support systems out of the traditional model used by the armed forces in during the Cold War period. This program began during the late 90s and early 2000s, representing acquisition and research examples of what scholars and leaders believed would be needed for the future national security environment.

Joint Tactical Radio System progression

The Joint Tactical Radio System was one of the big, keystone programs meant to propel the U.S. military into the 21st century. This program would allow for units to communicate with one another with ease and increase the amount of data to increase situational awareness. All of this would be necessary to meet the demands of Joint Vision 2010 and the force of the 21st century. The program, while innovative, was mismanaged and because of administrative as well as technical challenges, progress toward a joint radio was slow

The Joint Tactical Radio System began in the mid 1990s as an attempt to reduce the number of different communications systems used in the United States military.⁸⁸ The Army wanted to be able to operate and revise plans during an operation, which was a limiting factor in the Gulf War.⁸⁹ Before the origination of the program, each service had their own communications solution, creating 25 to 30 separate systems that did not interoperate.⁹⁰ The military believed the Joint Tactical Radio System, which would introduce commonality and reduce soldier workload, would only require 300,000 radios for the entire Armed Forces enterprise, rather than the over 700,000 they were using at the time.⁹¹ The system was based on an idea of a networked, software-defined radio, which could communicate over multiple different frequencies and waveforms. The system would also be compatible with the U.S. legacy systems and certain close allies, who operate with the United States.⁹² Joint Tactical Radio System was an integral part of expanding the Global Information Grid, and an enabler for a network-centric concept of operations the Department of Defense was shifting towards.⁹³ The program was spread across five separate platforms, led by separate services. Those five areas were Ground Vehicle and Helicopters, Hand Held Radio, Fixed Site and Maritime Radios, High Performance Aircraft, and Handheld, Dismounted Small Form Factor Radios. The U.S. Army, Navy, Air Force, and U.S. Special Operations Command would develop these

⁸⁸Feickert, Andrew. *The Joint Tactical Radio Systems (JTRS) and the Army's Future Combat System (FCS): Issues for Congress*. RL33161 Vol. Washington, D.C.: Congressional Research Service, 2005. Print.

⁸⁹ Axe, David. *Failure to Communicate: Inside the Army's Doomed Quest for the 'Perfect' Radio*. Online: The Center for Public Integrity, 2014.

⁹⁰ Peter A. Buxbaum, "Jitters Over JTRS," *Armed Forces Journal*, July 2005, p. 31.

⁹¹ Brewin, Bob. "Pentagon Shuttters Joint Tactical Radio System Program Office." *Nextgov* August 1 2012.

⁹² Feickert, Andrew. *The Joint Tactical Radio Systems (JOINT TACTICAL RADIO SYSTEM) and the Army's Future Combat System (FCS): Issues for Congress*. RL33161 Vol. Washington, D.C.: Congressional Research Service, 2005.

⁹³ Gallagher, Sean, and Larry Loeb. "Shifting Frequencies: The Joint Tactical Radio System is a Key Element in Department of Defense's Shift to Network-Centric Operations." *Defense Systems* Mar 24 2008.

systems simultaneously.⁹⁴ All of these software-defined radios would be designed to work with the Army's Future Combat System (appearing later in this article) and act as an enabling system for the networked concept of the system.⁹⁵

After the Army completed significant tests to prove the concept of Joint Tactical Radio System, the Department of Defense gave Boeing a two million dollar contract for the initial steps in the program.⁹⁶ Boeing embarked on creating one radio to answer the Army's call for a comprehensive solution. This program began hitting technological issues, as the over 30 waveforms the Joint Tactical Radio System was supposed to handle and process all required different technological answers and there were physical barriers to incorporating them into one, compact design.⁹⁷ The Department of Defense reorganized the program multiple times in an attempt to rein in costs and increase oversight. The most significant change was the division of the systems before 2004. This allowed for more defense contractors to enter the competition, increasing competition, but the problems still continued. Of particular concern was the Ground Mobile Radio (GMR). The GMR and a smaller version for individual troops were supposed to be small enough to be incorporated into a tactical link to far off assets.⁹⁸ In 2005, the Government Accountability Office (GAO) released a report addressing the technological challenges that were causing delays and cost over-runs, some of which

⁹⁴ Feickert, Andrew. *The Joint Tactical Radio Systems (JTRS) and the Army's Future Combat System (FCS): Issues for Congress*. RL33161 Vol. Washington, D.C.: Congressional Research Service, 2005.

⁹⁵ Ibid.

⁹⁶ Axe, David. *Failure to Communicate: Inside the Army's Doomed Quest for the 'Perfect' Radio*. Online: The Center for Public Integrity, 2014.

⁹⁷ Ibid.

⁹⁸ Ibid.

breached Nunn-McCurdy.⁹⁹ Specifically the GAO cited the weight and power requirements as being some of the biggest issue with the program. The Joint Tactical Radio System, which was going to be incorporated into the Future Combat System, a proposed new family of ground combat vehicles, needed to hit specific weight and power requirements to work with the program. Specifically, the FCS underwent a significant weight reduction to work with tactical transports meaning the Joint Tactical Radio System needed to weigh less. With the size, weight, and power consumption exceeding requirements, the FCS and Joint Tactical Radio System would need a redesign to fit into the force.¹⁰⁰ Boeing continued to struggle to build the GMR, one of the 5 parts of the program, which was having the most trouble. The GMR that they did develop tipped the scales at over 200 pounds and took significant time to warm up, transmit, and decipher messages, which is not well suited for combat situations.¹⁰¹ In 2011, the Obama Administration cancelled the biggest aspect of Joint Tactical Radio System, the GMR, citing cost overruns and technological challenges.¹⁰²

Warfighter Need and Response

It was clear the U.S. Military needed to change the way they communicated during operations. During the first Gulf War, exercises, and training, units still faced had limited abilities to communicate. This meant that plans were always static, targets could not be updated, and the fog and friction of war was greater than commanders wanted. In

⁹⁹ Arena, Mark, and Irv Buckstein et. al. *Department of Defense and Commercial Advanced Waveform Developments and Programs with Multiple Nunn-McCurdy Breaches*. MG1171z5 Vol. Rand Corporation, 2014.

¹⁰⁰ Government Accountability Office. *Defense Acquisitions: Resolving Development Risks in the Army's Networked Communications Capabilities is Key to Fielding Future Force*. GAO-05-669 Vol. Government Accountability Office, 2005.

¹⁰¹ Gallagher, Sean. "How to Blow \$6 Billion on a Tech Project: Military's 15 Year Quest for the Perfect Radio is a Blueprint for Failing Big." *ARS Technica: Technology Lab* 6/18/2012 2012.

¹⁰² Bloomberg News. "Department of Defense Axes Ground Mobile Radio Portion of JTRS Program." *Defense Systems* Oct 17, 2011 2011Print.l

theory, a radio like the Joint Tactical Radio System would largely solve this problem. Moreover, the U.S. military did not have the luxury of time when developing this system. The U.S. military engaged in combat in Iraq and Afghanistan a few short years after the start of this program and needed solutions fast. The new advanced way of communication was not ready for operational use when the U.S. military deployed to Iraq and Afghanistan. The concept behind Joint Tactical Radio System, the net-centric war, did not have legs to keep up with the quick pace of operations. The U.S. deployed troops with untested technologies and left critical gaps in ISR and intelligence capabilities, which theoretically should have been addressed with the new suites available to the war fighter. Mechanized units left their staging areas with tracking devices, unparalleled satellite coverage, electronic eavesdropping capabilities, and connectivity. It was all too common, especially in the beginning of the Iraq war, when large formations raced across the desert, for these systems to fail and leave soldiers to depend on traditional tactics or worse leave them vulnerable because they tried to utilize the revolutionary technology.

¹⁰³ Services needed to flex and buy radios to fill the gap that the Joint Tactical Radio System left as it did not meet its schedule while still providing some technical solutions. In both Iraq and Afghanistan, the U.S. military has needed the help of competitors to the Joint Tactical Radio System and the GMR system specifically to fill the communications gap. Harris Corporation became a stalwart in the urgent supply of radios, which could operate in multiple wavelengths. The AN-117G, which can be bought for a fraction of the cost of the Joint Tactical Radio System GMR, proved to be a soldier preferred radio, in which the military spent millions of dollars procuring on top of the GMR systems. Other rivals to the Joint Tactical Radio System provide solutions at a fraction of the costs, while

¹⁰³ Talbot, David. "How Technology Failed in Iraq." *MIT Technology Review* (2004).

providing largely similar capabilities.. One major issue with this approach though is the radios do not contain open architecture and the 117G radio's main waveform is Harris Corporation proprietary technology. Although the Harris 117G radio can work with some of the older, joint wavelengths, the radios wavelength limited what systems it was compatible with..¹⁰⁴ Harris offered to license the wavelength to the U.S. government for defense use, but that never moved forward.¹⁰⁵

The Joint Tactical Radio System ultimately restructured into Joint Program Executive Office (JPEO) Joint Tactical Radio System, with only three technologies, the AMF, HMS, and MIDS system surviving. More importantly the Joint Tactical Radio System network domain survived to be renamed to the Joint Tactical Networks Program (JTNC). This domain is critical for advancing the U.S. military's vision of future communication, as it will support secure, interoperable wavelengths, which the warfighter can use with commercial and military solutions.¹⁰⁶

Use of Benchmark Technology

The concepts that the Joint Tactical Radio program developed were useful as stated above, interim solutions used the technology and theory behind open architecture and integration of multiple wavelengths for military communications. Services used these concepts and discoveries provided by the program to build new networks.

An interesting study is the United States Marine Corps experience with a next generation communication system. Faced with the same communications problem, the service embarked on an in-house campaign to find a solution. What the USMC came up

¹⁰⁴ Brannen, Kate. "As JTRS Schedule Slip, Outside Radios Gain Ground with U.S. Army." *SpaceNews* October 4, 2010.Print.

¹⁰⁵ Ibid.

¹⁰⁶ Rosenberg, Barry. "From Radios to Waveforms: How JTRS is making itself as JTNC." *Defense Systems* September 06, 2012 2012Print.

with was CONDOR. The Marine Corps introduced this system around 2005. They needed a technology that could operate as a bridge between old and new technology while they were equipping with new systems. Through their own research and development they produced a system that satisfied certain requirements of future communications needs and was a useable solution. Better yet, the USMC used existing off the shelf technology to complete the project.¹⁰⁷

The Marine Corps also used commercial technology to meet their communications needs. The Marines experimented with and ultimately used the Iridium communication network to enable troops to communicate over a long range and in an encrypted fashion. The program eventually yielded the Distributed Tactical Communications Systems (DCTS), which gave troops a push-talk ability, a 250-mile coverage, secured networks, and gave the ability for multiple users to interact on the same channels and wavelength. This allowed for theater wide communications, real time distribution of data and empowerment of sensor suits, and increase in effectiveness for ground troops.¹⁰⁸

Did pursuit of revolutionary technology harm immediate need?

The Iraq War in 2003 was the first large scale ground operation taken in a long established post cold war era. The Department of Defense was apt to use their new-networked war doctrine and technology to prove that the RMA they had pursued produced real tactical and strategic advantages.¹⁰⁹ The Joint Tactical Radio System was important to this concept, as it would provide the technical practice to the concept, but as

¹⁰⁷ Lawlor, Maryann. "Marines Build a Transformational Bridge." *Signal* (20014)Print.

¹⁰⁸ Defense Industry Daily staff. "The U.S. Military's DTCS 'Netted Iridium' Program." *Defense Industry Daily* (2011)Print.

¹⁰⁹ Fiedler, David M. "HF Combat Net Radio Lesson Learned again." *Army Communicator* 29.4 (2004): 32. Print.

provided above, the program did not develop as quickly as needed. The military had to rely on commercial technology and service innovation to bridge the gap and meet the need of the war fighter. This propelled the Department of Defense forward and helped the warfighter meet the new challenge facing them on the battlefield.

The network centric war that the Department of Defense pursued because of Joint Vision 2010 did in fact develop, although programs such as Joint Tactical Radio System did hold the military back due to the programs issues. Joint Vision 2010 did predict a RMA. The proliferation of communications technologies leveled the playing field and allowed non-state and proto-state actors to threaten U.S. military dominance. In Iraq, small cells of terrorists and anti-U.S. militia forces were able to significantly affect U.S. operations in the region and require the U.S. military to make alternate plans of operations and pursue alternate technologies. This was all happening while the Joint Tactical Radio System program experienced significant delays.

The software defined radio and open architecture systems that Joint Tactical Radio System helped to develop and spur are key to the future of the United States military, and the partial failure of the Joint Tactical Radio System was key to creating these technologies. The University of Maryland, on a partial grant from the Naval Post Graduate School, evaluated the Joint Tactical Radio System and pointed out how the restructurings taught the U.S. military some important lessons. Mainly, the program pointed out that planning, evolution, industry competition, and acceptance of partial solutions to requirements rather than forces technically infeasible solutions on to industry can be beneficial to overseeing successful programs.¹¹⁰

¹¹⁰ Gansler, Jacques, Lucyshyn, William, and John Rigilano. *The Joint Tactical Radio System: Lessons Learned and the Way Forward*. UMD-AM-11-199 Vol. University of Maryland, 2012.

The Department of Defense is now pursuing a change in culture to bring about open architecture and system interoperability to allow for a more agile force. Instead of continuing to work with contractors who usually end up owning the rights to the systems and all follow on development, the U.S. military is looking for solutions that are more modular, and fit together with families and systems of systems.¹¹¹ The closed mindset of the previous decades created the problems Joint Tactical Radio System sought to fix. The U.S. military is now pursuing policies to make sure that same issue of system incompatibility does not happen again.

Looking back to 1997, U.S. military leaders were correct in predicting a need for a systems of systems approach. They saw the threat and the challenges ahead, which was a largely accurate assessment, and realized what actions needed to be taken to fix the way forward. Joint Tactical Radio System exhibits the U.S. military's response to a need for new technology, and after reviewing the evidence, it is a necessary program to spur change. Joint Vision 2010 did Open architectures, software defined radios, and families of systems. More broadly, the failure of the Joint Tactical Radio System did lead to important lessons learned in how to acquire and develop technology in the 21st century. The military had to think around the problem, which led to the USMC reworking the Iridium network and changing how they conducted ground communications, and the U.S. military as a whole needed to work with other industry to integrate radio systems that did not satisfy all of the goals the Joint Tactical Radio System program set out for. These adaptations proved the benefits of flexibility in a developing technological landscape.

¹¹¹Serbu, Jared. "Department of Defense Brings Culture of Open Architecture to a World of Proprietary Systems." *Federal News Radio* November 13, 2013.

Chapter 3

Modern Acquisition and Cost Efficiencies

Taking the lessons from the previous examples, the Department of Defense has to face down fiscal and technological challenges. The political and fiscal environment is not as favorable to support unjustified military spending. Realizing that Congress just debated and passed military spending legislation at historic levels, the extra funding will not be sustained and Congress can change their path in spending. Every dollar counts in this fiscal environment. At the same time the United States is facing unprecedented threats across the globe ranging from state actors like Russia and China who want to reassert themselves while disturbing the rules based order the U.S. and allies created post World War Two. China and Russia are angling to do this by projecting power in their regions and muscling the United States out. On the other end of the spectrum, the United States is faced with low intensity conflicts from violent non-state actors, such as ISIS and Al-Qaeda, which pose a challenge into the future. Within this, the U.S. Department of Defense needs to continue to pursue modernization policies that maintain their dominance over the entire spectrum of threats. The 3+2 strategy that the Trump administration proposed in the National Defense Strategy will require a large spectrum of capabilities, all of them costing precious resources. With major defense acquisition programs like the F-35, CVN-79, and many calling into question Defense spending and focusing the modernization debate around programs that are continually over budget, delayed, and underperforming, the Department of Defense needs to reexamine its acquisition procedures. Congress, playing its traditional role as overseer, is trying to implement some of the most monumental changes to the Department of Defense's

internal acquisition process, but services also need to reexamine how the ‘innovate.’ This section seeks to examine the services ideas on innovation while controlling costs. The critical question needing to be answered is ‘How can the Department of Defense continue to innovate and field superior weapons systems while maintaining predictability in cost and delivery?’ This section hypothesizes that services need to renew focus on developing and improving existing technology through evolutionary acquisition and spiral development instead of embarking on ‘clean-sheet’ programs that have a history of underperforming on budget and schedule. First, the section surveys the existing literature on the subject and then moves into two comparative case studies. The first case study focuses on the DDG-1000 v. the DDG-51 and the second focuses on the F/A-18 Super Hornet vs. the F-22 Raptor. Although many studies have compared and contrasted these programs, my research takes it a step further to see if incremental innovation produces the results the U.S. needs to maintain its superiority into the 21st Century.

Literature Review

The world of defense acquisition reform is very complicated and there is no single solution to the problem. Scholarship on the issue ranges from explaining bureaucratic mismanagement to ever evolving requirements, to over-zealous testing, evaluation, and design as a reason for high expense and slow results. My review looks into many pieces of existing scholarship, but center on how bureaucratic inefficiencies and over-zealous requirements lead to a slow and expensive process as causing issue in the process.

Mismanagement

John P. Kotter, in his article “Why Transitions Fail” highlights some of the issues that large-scale corporations and organizations face when attempting to transform

processes. He believes that groups fail to transform because of a combination of factions including “not establishing a sense of urgency,” “lacking a vision,” and “not anchoring institutional change.” To the casual observer, a bureaucratic institution such as the Department of Defense faces all of these challenges, especially when its budget is seldom threatened by Congress. He argues that if an organizations to make a transition, it needs to follow through and institutionalize changes rather than allow the system to settle into status quo.¹¹² Relating this piece to the Department of Defense is clear. The Department of Defense must not allow old Cold War era acquisition systems and thinking entrench itself against innovative, leaner processes to optimize for operations in the 21st century.

Col. William Fast, USA (Ret) writes in *Improving Defense Acquisition Decision Making* about the correlations of requirements and miscommunication between the acquisition decision makers. Currently, there are three major government bodies that deal with traditional Program of Record acquisitions, or large, planned acquisitions that will be integrated in the force. Previous acquisition reformed aimed at achieve private sector like efficiencies, but ended up creating a process where multiple offices guide requirements, budgets, and milestones. This complex process is compounded by lack of managers in senior leadership who either centralize control of the project or decide on requirements so late that they have a negative effect on the project. Instead of making the whole process efficient, this just stove pipes decision-making and does not allow for projects to enjoy predictability. Colonel Fast suggests that departments pursue their own

¹¹² Kotter, John P. "Leading Change: Why Transition Efforts Fail." *Harvard Business Review* (1995)

acquisition strategies and link the requirements and budgeting process closer together to facilitate more communication.¹¹³

Over-zealous requirements

Thomas Donnelly, who at the time of publication, was co-director at the conservative leaning think-tank American Enterprise Institute, takes aim at the overly rigorous testing battery required of all new equipment. He uses the Bradley Infantry Fighting Vehicle, the M1 Abrams, the F-15 and the Littoral Combat Ship, the three former combat tested and proven vehicles, and the former being a new weapon system, as his prime case studies. During the development, many critics used the Director of Operational Test and Evaluation as cover to prove that the systems were inferior and too dangerous for our troops to use. He builds his argument to show how the Operational Test and Evaluation office exists only to say no, and that Congress should undue this heavy burden on the Department of Defense Acquisition system. Testing is a necessary quality control for programs and systems, but having such unachievable standards creates a situation where perfect is the enemy of the good and costs spiral trying to achieve this.¹¹⁴

Jacques S. Gansler and William Lucyshyn argue that the Department of Defense, in many of the same ways all executive agencies are, embarked on a way to innovate their process the lose the true objective and stick to strict regulations which means they maintain the rigid structure Department of Defense needs to shed. They credit the Department of Defense with showing flexibility due to the Global War on Terror, but

¹¹³ Fast, COL. William USA (Ret.). "Improving Defense Acquisition Decision Making." *Defense Acquisition University* (2010).

¹¹⁴ Donnelly, Thomas. "They Only Say no." *The Weekly Standard*, May 29, 2015, 2015.

highlight how the acquisition landscape is significantly changing due to the higher percentage of services bought rather than goods. Gansler and Lucyshyn see this change in the marketplace as the biggest issue in procurement. The current acquisition system is optimized to purchase goods, and the Department of Defense does not have an efficient process to procure services. They present eight specific solutions ranging from allowing commercial opportunity and reducing monopoly to better oversight and effective execution of contracts.¹¹⁵ The Department needs to show flexibility to the new nature of procurements. Just as the character of warfare changes and the Department and Armed Forces adapt, so does the economy and the Department needs to adapt to new ways to buy.

Others think that over-reliance on private sector concepts are the downfall of the system and requiring competition to be used in an inappropriate manner can actually lead to increased cost. Todd Harrison argues in his piece “*The Effects of Competition on Defense Acquisition*” that unneeded competition can cause an increase in program cost as the Department of Defense foots the bill to build the developmental prototypes. Although this is not the case in all situations and can lead to cutting edge achievements, competition can also incentivize contractors to misrepresent price just to win a bidding war. He bases this on the fact that the Department of Defense is a customer and a market at the same time, so the same rules cannot apply as they do in the private sector.¹¹⁶ This highlights a big problem throughout the entire defense process. The Department is a hard customer to work with, and innovative new companies, such as those on the bleeding

¹¹⁵ Gansler, Jacques S. and William Lucyshyn. *Eight Actions to Improve Defense Acquisition*. University of Maryland: IBM Center for the Business of Government, 2013.

¹¹⁶ Harrison, Todd. "The Effects of Competition on Defense Acquisitions."2012.

edge of critical technologies, are pushed away from the marketplace, not for lack of funding, but for the difficulty of doing business with Defense Department..

What should the Department do?

The Department will face the question: ‘How can the Department of Defense continue to innovate and field superior weapons systems while maintaining predictability in cost and delivery.’ In a budget-constrained environment, the Department will have to prove to Congress and the public that it is using every defense dollar responsibly. The Department will also only have a few shots to perfect programs and deliver new combat capabilities. Unlike in older days, the Department may not have the money to correct mistakes or plug holes created by capability gaps. The Department will need to reduce risk to make sure they can obtain the items they need on budget and on schedule. By looking at select, but major, programs that are designed to advance and affect the United States military combat capability, and are mission critical for current and future strategy, there is a pattern that revolutionary technology does not provide the numbers or capabilities needed by the Department. Conversely, on the fielding of proven, evolutionary capabilities and platforms does provide the quantities and combat power needed to meet 21st century threats.

Methodology and Definitions

It is difficult to compare and contrast every single defense acquisition project. Different services have different requirements and acquisition preferences, and even though these projects follow uniformed acquisition regulations and processes controlled by the Secretary of Defense, each have very unique characteristics.

This study examines the F-22 and the F/A-18 because the programs began their development around the same time, were addressing a major capability upgrade, and the systems were needed in large quantities.¹¹⁷

This examination is followed by the DDG-51 and DDG-1000. These two acquisitions represent a control group in my research. They are both Navy programs to address an ever-evolving technological need for the U.S. Navy and important to the Navy future shipbuilding and fleet plan, but in this case, the Navy moves forward with my hypothesis of innovating on existing technology.

As the DDG-1000 faced drastic cuts, the Navy is moving forward with the DDG-51 Flight III – the fourth iteration of the original design – to update the ship with the technology to face 21st century threats and provide the US Navy with budgetary latitude to meet fleet demands.¹¹⁸ The controlled comparison is set to test the relationship between the degree of innovation and the efficiency of the program. This study will be measuring the degree of innovation qualitatively by seeing how much of the program requires the development of immature technological and developmental concepts and suites of capabilities sought, Efficiency will be measured by how accurate forecasts for costs, delivery timeframe, and total quantity delivered.

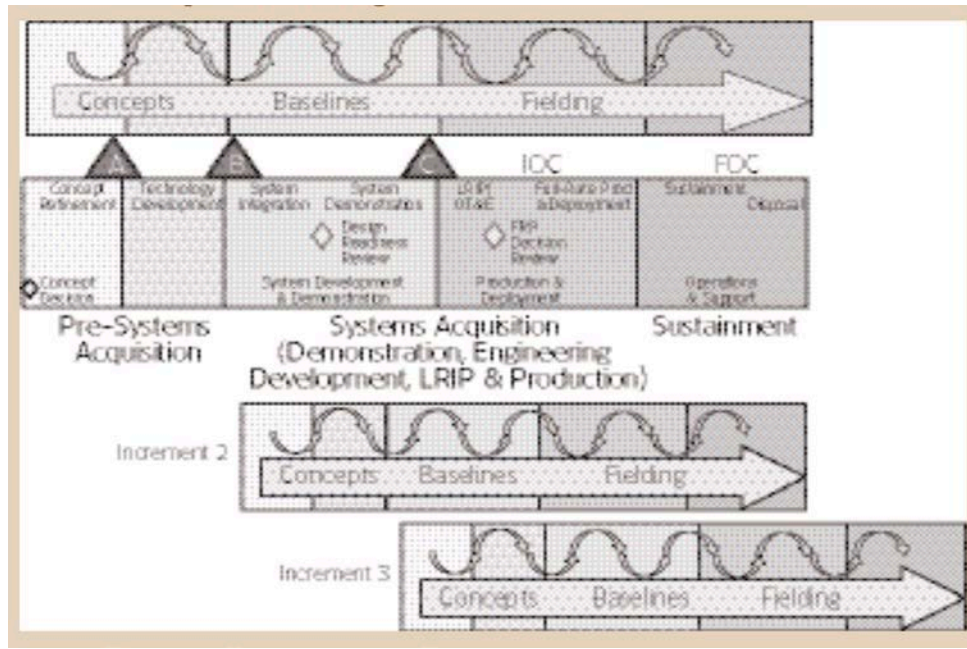
Definitions

In the subsection below, there is a basic guideline most commonly used during the acquisition process (Figure 1.2), and explanations of both evolutionary acquisition and

¹¹⁸ O'Rourke, Ronald. *Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress*: Congressional Research Service, 2016.

spiral development. These two acquisition models, while used in the Department of Defense, represent the development strategy examined in this paper.

*Acquisition Chart (Figure 1.2)*¹¹⁹



Evolutionary Acquisition

Evolutionary acquisition is nothing new to the Department of Defense. This acquisition strategy became a tool in the Department of Defense acquisition guidelines in 1995.¹²⁰ As demonstrated in figure 1.3, evolutionary acquisition is a way to make weapons systems open to adapting to added demands and capabilities.¹²¹ This strategy gives the Department of Defense the ability to keep its programs in a space where they are better suited to changes in funding, threat environment, evolved technologies, and Congressional oversight.¹²²

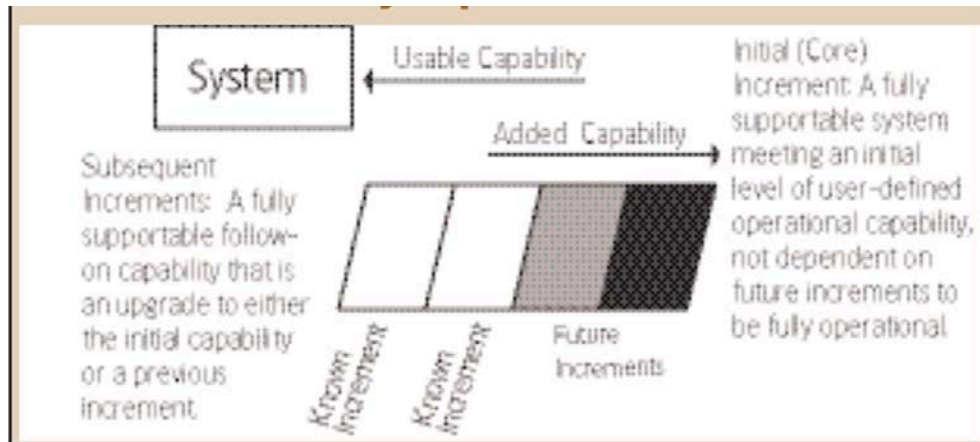
¹¹⁹ Farkas, Kenneth and MAJ Paul Thurston (USAF). "Evolutionary Acquisition Strategies and Spiral Development Processes." *PM Magazine*, July-August 2002, 2003, 10-14.

¹²⁰ Ibid., 10

¹²¹ Ibid., 11

¹²² Ibid., 12

*Evolutionary Acquisition (Figure 1.3)*¹²³



Spiral Development

Spiral development is a process when developing systems and technology through conception, baseline testing, and fielding.¹²⁴ Spiral development is “an iterative process that includes collaboration with the stakeholders/users and continuous feedback to provide the best possible capability for a specific increment.”¹²⁵ This type of development allows the Department of Defense to reduce risk in the system as the development of add on technology and capabilities would be inherently less complex and require less resources than a complete acquisition of a brand new capability.

F/A-18 Super Hornet and the F-22 Raptor

These planes represented a solution to modernize the combat power into the 21st century. This study fully realizes the shortfall of comparing both of these platforms, the designs of both aircraft are meant to address a separate threat, operate in different environments, adapt to different contingencies, and play a different role in their respective services arsenal. What can be derived from their study is how stakeholders

¹²³ Ibid.,13

¹²⁴ Ibid.,12

¹²⁵ Ibid.,13

received the programs, and how they addressed the needs they were supposed to fill.

Looking at both of these programs, which had a similar, enough acquisition timeline for this study's purpose, readers can surmise trends. Both of these programs navigated a budget-constrained environment in the 1990s, but with two very different results. These platforms were built to meet different requirements, but were pursued at similar times, but through different acquisition strategies.

F/A-18E/F

The Hornet and Super Hornet are still in the Navy and Marines fleet today. Initially starting as an Air Force program, the Navy was able to make the fighter its own.¹²⁶ The program developed out of Navy and Marine Corps needs to make up for the shortfalls in the legacy F/A-18A-D.¹²⁷ The Super Hornet is one of the most successful aviation programs in the service's history.¹²⁸ The Navy wanted a new fighter that had a longer range, increased speed, and ability to recover more ammunition from sorties, a heavier combat payload, and increased survivability.¹²⁹ On top of this, the Department of Defense issued a directive in 1987 instructing both the US Navy and US Air Force to fill the fighter gap that would be created while waiting for the USAF F-22 and the then planned US Navy, A-12, which was subsequently cancelled.¹³⁰

¹²⁶ Bottelson, CDR Jay. "Requirements and Cost Stability: A Case Study of the F/A-18 Hornet Program." *Defense Acquisition Research Journal: A Publication of the Defense Acquisition University* (October 2011, 2011): 390-201

¹²⁷Younossi, Obaid, David Stem, Mark Lorell, and Frances Lussier. *Lessons Learned from the F/A-22 and F/A-18E/F Development Programs*. Santa Monica, CA: RAND Corporation, 2005.

¹²⁹ Rodrigues, Louis J. *Navy Aviation: The F/A-18E/F Will Provide Marginal Operational Improvement at High Cost*. Washington, D.C.: Government Accountability Office, 1996

¹³⁰ "F/A-18E/F: Changing Roles." *Flight Global*, 20 January 1999, 1999.

In response the United States Navy commissioned the “Hornet 2000” study, which provided 4 options to upgrade the Hornet fleet.¹³¹ The configuration picked represented an incremental upgrade, providing a cost effective solution, and address the upgrade issues facing the legacy Hornets at the time.¹³² This program, initially supposed to be a stop gap for the future capability, turned out to be the centerpiece of the future of naval aviation when, in 1991, the Department of Defense significantly reduced the amount of aviation projects the Navy would be able to pursue. Instead of the carrier deck being filled with new fighter and attack aircraft like the upgraded F-14D and the A-12, the F/A-18E/F would be the future.¹³³

In 1992, the F/A-18E/F Super hornet entered the Engineering Manufacturing and Design (EMD) stage of the acquisition process, as the Legacy Hornet already proved the viability of the concept. The Navy began procuring the larger more capable Super hornet in FY 1997. The F/A-18E/F first arrived in the defense community in September 1995. The aircraft met all of the Navy’s stated capabilities and requirements. It was able to accomplish this on budget and underweight.¹³⁴ The aircraft participated in its first combat sortie in November 2002, when Super hornets conducted airstrikes inside of Iraq’s no fly zones. The Super hornet performed superbly, dropping twice the amount of ordinance of other aircraft in the air wing and costing less to operate per flight hour.¹³⁵ As of the FY17

¹³¹ Elliott, Simon. "MDC Reveals New Hornet 2000 Details." *Flight International*, 12 September 1999, 1999, sec. Technical: Defense.

¹³² "F/A-18E/F: Changing Roles." *Flight Global*, 20 January 1999.

¹³³ Ibid

¹³⁴ "United States Navy Fact File: Hornet Strike Fighter." United States Navy, 2016.

¹³⁵ Ibid.

NDAA debates, the U.S. Navy is still actively pursuing Super hornets to fill critical capability gaps and shortfalls presented by a delayed F-35C.¹³⁶

Currently the Navy plans to have F/A-18A-Ds in the fleet until the mid-2020s and F/A-18E/Fs in the fleet until 2035. With the continuing delays of the F-35C Lightning II, the US Navy is considering pushing these aircraft past their original retirement date, and even modifying them more to fill critical roles in future carrier air wings.¹³⁷ The Selected Acquisition Report (SAR) from 2012 on the F/A-18E/F records the program as costing \$50.05B in total and the Department of the Navy procuring a total of 552 Hornets.¹³⁸

F/A-22

In the 1980s the United States Air Force looked to replace the F-15 Air Superiority fighter with a next generation aircraft. This aircraft was supposed to field new technology and field capabilities that would be able to defeat all known and future air threats, and also provide a limited ability to strike ground targets.¹³⁹ The U.S. Air Force saw some of the newer Soviet jets having aerodynamic capabilities that would challenge the current inventory and possibly best them in future fights. The Air Force determined a need for the Advanced Tactical Fighter (ATF), through studies and Air Force determination. The leaders at the time believed that a new materials, stealth technology, and different aerodynamic qualities would make fighters like the F-16 and F-15 obsolete

¹³⁶ Gould, Joe. "Lawmakers: Give US Navy More F/A-18s." *Defensenews*, March 2, 2016.

¹³⁷ Majumdar, Dave. "US Navy's Sixth-Generation F/A-XX Fighter: Just a 'Super' Super Hornet?." *The National Interest*, July 26, 2016, 2016, sec. The Buzz.

¹³⁸ *Select acquisition report (SAR) F/A-18E/F*. 2011. Defense Acquisition Management Information Retrieval (DAMIR), RCS: DD-A&T(Q&A)523-549.

¹³⁹ Gertler, Jeremiah. 2013. *Air force F-22 fighter program*. Congressional Research Service, RL31673.

by the early 2000s. In 1986, the Air Force put out a request for proposal.¹⁴⁰ It took four years to build and test airframe and propulsion prototypes, and in 1991 the Air Force awarded a \$10 billion contract to move the F-22 program forward. From the inception of the program, the design was expected to be challenging. The Air Force wanted a fighter that would dramatically reduce pilot workload, bring online new sensor capability, and change the character of air war. Throughout its decades long process Congress and the Department of Defense altered funding, requirements, and program cost estimates, making it more difficult to justify the cost of the programs. To add to this, the Cold War's cessation altered the strategic calculus in the minds of many policy makers. The cuts in defense spending made the Department of Defense and Congress hungry for programs to reduce to realize cost savings. The program endured multiple funding cuts, directed by Congress, because of cost growth and questions about future need. At one point the House Appropriations committee suggested zeroing out the program (Advance Tactical Fighter version) because of cost growth and justification issues.¹⁴¹

The Air Force plan for the F-22 was to replace the F-15 with 750 F-22 fighters. The number was severely reduced, until finally, in FY 2007, Congress authorized a final quantity of 183.¹⁴² The aircraft, first flying in 1997 – a full seven years after the YF-22 concept was demonstrated and evaluated. In total this aircraft program cost \$67.3B in FY 2010 dollars for a total of 179 aircraft.¹⁴³ The aircraft serves in combat roles and is seen

¹⁴⁰ Pike, John. "Military." *F-22 Raptor History*, Globalsecurity.org , www.globalsecurity.org/military/systems/aircraft/f-22-history.htm

¹⁴¹ Pike, John. "Military." *F-22 Raptor History*, Globalsecurity.org , www.globalsecurity.org/military/systems/aircraft/f-22-history.htm

¹⁴² Gertler, Jeremiah. 2013. *Air force F-22 fighter program*. Congressional Research Service, RL31673.

¹⁴³ Ibid.

as a strong forward presence marker for the United States, but in such limited numbers, the airframes and the aircrews are a very precious resource.

These delays and cost overruns were created because of the challenges that bringing a new, revolutionary technology online cause. Specifically the F-22 had issues with developing its engine, perfecting its stealth features, integrating the avionics, and building the electronic warfare and protection packages necessary to help it survive a modern combat situation.¹⁴⁴ These cost overruns and schedule delays made the F-22 program a ripe target for Congress and the Obama administration to target and an unnecessary expenditure. Of particular significance, an amendment vote during the deliberation of the fiscal year 2010 National Defense Authorization Act removed \$1.7 billion dollars in authorization for 7 more F-22 frames. This vote helped to solidify the administrations talking point that the U.S. military should not be investing in cold war technology and instead invests in technologies for gray zone and low intensity conflicts.¹⁴⁵

DDG-51 v DDG-1000

DDG-1000

The DDG-1000 was developed by the United States Navy under the guise of the DD(X) program and is designed for land attack and operation in the littorals.¹⁴⁶ The ship will provide a much-reduced radar cross-section as well as an increased survivability

¹⁴⁴ *TACTICAL AIRCRAFT: Concurrency in Development and Production of the F-22 should be Reduced*: Government Accountability Office, 1995.

¹⁴⁵ Drew, Christopher. "Obama Wins Crucial Senate Vote on F-22." *New York Times*, July, 21 2009, 2009, sec. Business Day.

¹⁴⁶ United States Navy fact file: Destroyer DDG. in United States Navy [database online]. 2016 [cited 7/13/2016 2016]. (accessed 7/13/2016).

against 21st century threat while “meeting validated Marine Corps fire support requirements.”¹⁴⁷ The program began in January 8th, 1995 when the DD21 program, which was planned to replace the older DDG-51, began its Cost and Operational Analysis. In January 1998, the U.S. Navy identified risks in the program such as a new hull and immature combat systems, but these developments would significantly reduce the profile, crewing requirements and lead to an overall cost savings over the DDG-51. The DD(x), which was now known as the DDG-1000 program, received authorization to enter low rate production, and the US Navy awarded the initial building contracts. In mid-year 2008, Congress began investigating an alternative to the DDG-1000 and, in February 2008, the President’s budget request modified the total procurement amount to three DDG-1000s. A United States Navy study known as the *Future Surface Combatant Hull Study* proved that an updated DDG-51 with new technology and structure upgrades will be the most cost effect solution to the Fleets future need.¹⁴⁸ The program subsequently was restructured to remove some of the riskier technology. Initially the program planned for the procurement of 32 ships, but the program, which was suffering cost overruns, saw incremental decreases in total procurement until the US Navy settled on 3 ships.¹⁴⁹ Currently the program has cost around \$22.4B, with a procurement cost of \$13.2B¹⁵⁰ The ship is not considered to be combat capable until FY 2019, which is almost 4 years past the Navy’s 2010 estimates.¹⁵¹ In part, these cost overruns were caused

¹⁴⁷ United states navy fact file: Destroyer DDG. in United States Navy [database online]. 2016 [cited 7/13/2016 2016]. (accessed 7/13/2016).

¹⁴⁸ *Selected acquisition report (SAR): DDG 1000 zumwalt class destroyer (DDG 1000)*. 2015. Defense Acquisition Management Information Retrieval (DAMIR), RCS: DD-A&T (Q&A)823-197.

¹⁴⁹ O'Rourke, Ronald. *Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress*: Congressional Research Service, 2016.

¹⁵⁰ Paccio, Anthony. "The Navy's \$22 Billion Stealth Destroyer is Delayed again." *Bloomberg*, April 14, 2016, 2016, sec. Bloomberg Technology.

¹⁵¹ Ibid.

by the U.S. Navy's risky approach to technology. The Navy was only able to bring 5 out of the 11 new technologies to a mature state by 2018, and much of this was due to the failure to validate any technology before incorporating it.¹⁵² This highlights the concerning nature of revolutionary technology and acquisition and the effects that burdensome requirements can have on a program. Program managers and designers wanted to build a ship that would change the face of naval warfare but instead dived headlong into a risky project without validating requirements and enabling technologies to a degree that would provide a more protected acquisition process.

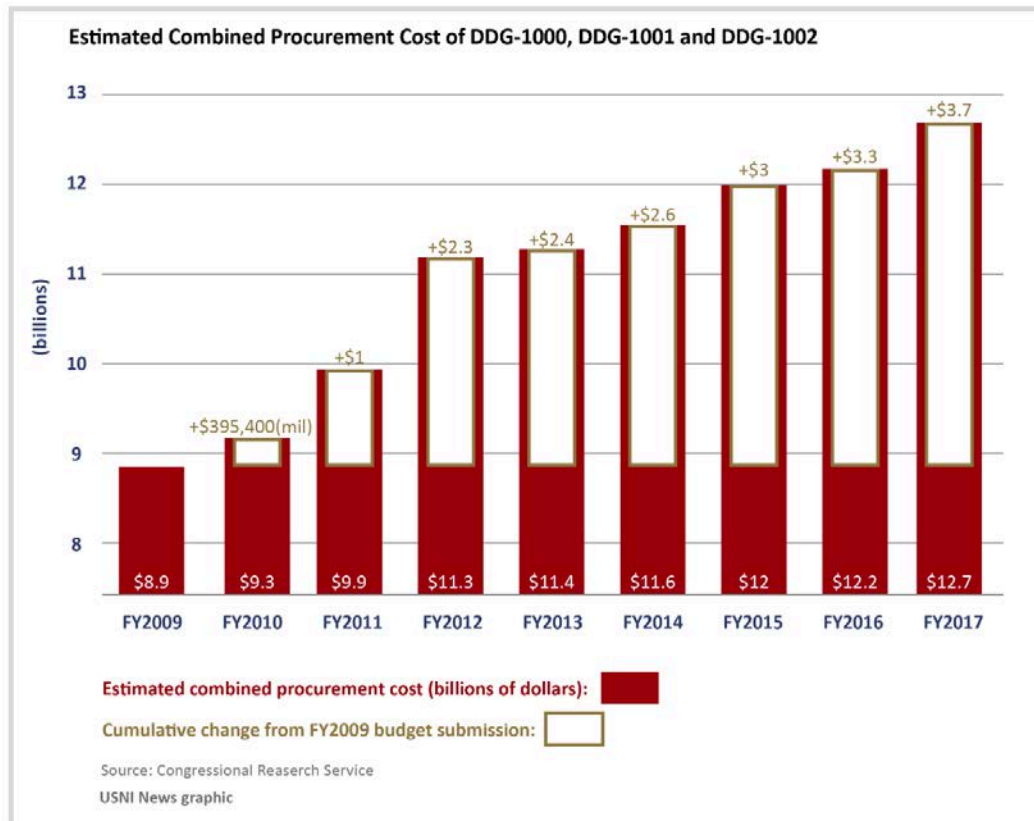
The DDG- 1000 faces different issues now. The mission that it was supposed to fulfill is no longer the stated purpose of the destroyer. The ship can no longer provide the ship to shore fire support it was designed to provide. The shells for the massive land strike guns that the ship is armed with does not have rounds to fire. The Long-Range Land-Attack Projectile (LRLAP) is way over budget and not cost effective to use in combat or procure in large quantities. The Navy had to rebuild requirements for the 3 ships in the fleet in a very rapid timeframe, using a rapid requirement model.¹⁵³

*Procurement cost growth (Does not include Research, Development, Test and Evaluation.)(Figure 1.3)*¹⁵⁴

¹⁵² DEFENSE ACQUISITIONS: Assessments of Selected Weapons Programs: Government Accountability Office, 2017.

¹⁵³ Eckstein, Megan. "New Requirements for DDG-1000 Focus on Surface Strike." 2018.

¹⁵⁴ LaGrone, Sam. "Navy Requires \$450 Million More to Complete Zumwalt-Class due to Shipyard Performance." *United States Naval Institute News*, April 6, 2016.



DDG-51

The US Navy started the DDG-51 program in the latter half of the 1970s. This ship produced is an AEGIS air defense system destroyer, which is able to perform multiple missions independently. The US Navy first procured the DDG-51 in 1985 and saw delivery in 1991.¹⁵⁵ The US Navy has a total of 62 in service and a total of 74 were delivered (based on FY 14 numbers) and is procuring more.¹⁵⁶ The DDG-51 has seen multiple spiral upgrades ranging from DDG-51 to DDG-51 Flight IIa. These improvements saw changes to the structure and equipment.

¹⁵⁵ O'Rourke, Ronald. *Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress*: Congressional Research Service, 2018

¹⁵⁶ Ibid.

The US Navy is now in the midst of developing and procuring the DDG-51 Flight III ship including an upgraded Air Defense and Missile Radar (AMDR).¹⁵⁷ The total DDG-51 program cost as of a 2015 SAR is \$98B with a total of 82 ships planned to purchase.¹⁵⁸

Congress is also more apt to support an acquisition program such as this, and even allow for the service to build in more flexibility. The 2018 National Defense Authorization Act authorized the United States Navy to enter into a multi-year buy of the ships, and put money into the program to allow for 3 ships to be purchased instead of 2, which was requested by the Navy. Senate and House Appropriators, who are in charge of writing the legislation that actually obligates the money from the United States Treasury, have not shown support to increasing the program, but there is support from key members.¹⁵⁹ This multi-year contract follows an initial authorization in 2013,¹⁶⁰ which authorizers and appropriators do not always support as they lose some aspects of their oversight power. Beyond the fact that a multiyear contract could potential save up to 10 percent in construction costs throughout the life of the contract, this shows that Congress trusts the program enough to the program the authority and tools it needs to move forward quickly.¹⁶¹

New versus improved?

¹⁵⁷ Ibid.

¹⁵⁸ *Selected Acquisition Report (SAR): DDG 51 Arleigh Burke Class Guided Missile Destroyer (DDG 51)*: Defense Acquisition Management Information Retrieval, 2015.

¹⁵⁹ Eckerstein, Megan. "DDG-51 Program Office Preparing RFP for Next Multiyear Buy; Will Include Options for Additional Ships." *USNI News*, December 19, 2017, 2017, sec. Budget Industry.

¹⁶⁰ O'Rourke, Ronald. *Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress*: Congressional Research Service, 2018

¹⁶¹ O'Rourke, Ronald. *Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress*: Congressional Research Service, 2018

The F/A-18 proved to be one of the more successful acquisition projects that allowed for the U.S. Navy to modernize its carrier fighter wing, while not embarking on a costly, often lengthy program to field new systems. The F/A-18E/F represents a fast, efficient way to get weapons to the warfighter. The Navy focused on improving a design that had already achieved success in the naval aviation environment, and were able to manage risk in the project because of this much more effectively. The F/A-18 represented an evolution in the design rather than a clean sheet design. The United States Navy was able to procure the aircraft in the quantities needed for its strategic and tactical goals, and it could do this at a palatable cost to the taxpayer. The F/A-18 Super hornet is continuing to develop and grow and is an integral part of the United States Navy future fleet. This year Boeing and the United States Navy embarked on a program to make the F/A-18 Super hornet Block III variant.¹⁶² The United States Navy also plans on buying close to 80 more F/A-18 Super hornets in the future to help make up for the strike fighter shortage it is facing on its decks.¹⁶³ The F/A-18E/F block III will be upgraded with the newest technology, such as Active Electronic Scan Array radars, Infrared Search and Track to detect stealth threats, and multiple other upgrades. It will be able to communicate with the 5th generation F-35, and will have advanced stealth features to help reduce its profile and allow it to operate far into the future.¹⁶⁴ These upgrades could see the F/A-18 series of aircraft serving vastly longer than planned and providing the capabilities and coverage

¹⁶² Giangreco, Leigh. "Block III Super Hornet Upgrades to Begin this Spring." *Flight Global*, 22 December 2017.

¹⁶³ LaGrone, Sam. "Navy's Planned 80 Super Hornet Buy could Grow After New Pentagon Strategy Review." *United States Naval Institute News*, June 15, 2017.

¹⁶⁴ Giangreco, Leigh. "Block III Super Hornet Upgrades to Begin this Spring." *Flight Global*, 22 December 2017.

of requirements that will continue to ensure the United States can respond to the contingencies it faces.

Schedule

The F/A-18E/F significantly fewer schedules slip between two important milestones in the acquisition.¹⁶⁵ In a budget restricted and time restricted environment, schedule slips and cost overruns can create issues. The United States Marines opted not to purchase upgraded Super Hornets and instead remained using the F/A-18 Legacy version, relying on the fact that the F-35 would be online to replace the aging jets. Fast forward to today, even though the F-35B (United States Marine Corps version) is in production, its price tag and issues with system immaturity have delayed it and resulted in increased reliance on legacy fighters. The USMC now needs to resort to extending the life of older aircraft, which is placing enormous strain on the older aircraft.¹⁶⁶ The data above shows that an aircraft that relies on spiral innovation off of a legacy platform, it will have a better chance of being delivered on time and schedule.

The DDG-1000 proves the same issues for the United States Navy. The ship is not expected to be combat capable until 2019, a full 4 years after the Navy anticipated in 2010. When the DDG-1000 system goes online, it will not do so in force as only 3 are being procured. This is also at astronomical cost, which in a budget conscience environment is unacceptable if the force wants to prove to some in Congress and the public that projects the Department spends on will prove to be effective. The DDG-1000, while providing a revolutionary platform, provides it at astronomical costs, and does not

¹⁶⁵ Younossi, Obaid, David Stem, Mark Lorell, and Frances Lussier. *Lessons Learned from the F/A-22 and F/A-18E/F Development Programs*. Santa Monica, CA: RAND Corporation, 2005.

¹⁶⁶ Kreisher, Otto. "Marines Taking 30 Hornets from Bone yard, Navy Inventory to Address Readiness Crisis." *United States Naval Institute News*, June 23, 2016, 2016, sec. Aviation.

work as intended. In juxtaposition, the data above alone shows that the DDG-51s provide a cost effective solution to provide ships en masse, and with spiral development and evolution of new technology, the DDG-51 system will be upgraded to remain lethal in the 21st century. Already the DDG-51 class of ships can provide a multitude of different capabilities while also providing the quantities to deploy. The Navy needs this as its ship purchases have not fulfilled need. The DDG-1000 and even the Littoral Combat ship represented programs that were filled with risk of new untested technologies and design. Costing time and money that the Navy will need to us for future requirements, the DDG-51 is left to fill the gap that still exists to this day.

Quantity an issue?

Although the F-22 is now operating in our active force and proving to be a significant asset in force deterrence, it was produced in extremely low numbers compared to what was initially planned. Because the USAF only procured 187 F-22s while retiring around 250 older fighters, the USAF is facing a smaller tactical fleet than planned.¹⁶⁷ The USAF wants to make up for this gap and continue to retire aircraft by purchasing more F-35, which reached IOC in August of 2016, but as of the time of this paper, the United States is still struggling to pay for the F-35 buys in large enough quantities to fulfill the needed force structure.¹⁶⁸

The United States Navy, in stark contrast, has a platform that meets the requirements of the force, in a number needed for the future structure of the force, and has the ability to buy more aircraft at a price that will not break the budget of the

¹⁶⁷ Eaglan, Mackenzie. "Fixing the Fighter Gap Facing the U.S. Navy, Air Force, and Air National Guard." Heritage Foundation. 2016.

¹⁶⁸ Weisgerber, Marcus. "F-35 is 'Ready for War;' Now the Air Force Wants More, and Faster." *Defenseone*, August 2, 2016.

Department of Defense. These issues are also faced with the U.S. Navy ship building campaign. Due to challenges across the globe, the United States Navy is planning on building a robust, large-numbered, blue-water navy to deal with threats and operations such as freedom of navigation to counter-piracy. The United States Navy is in need of a much-expanded navy, according to their shipbuilding plans by the 2020s.¹⁶⁹ The DDG-1000s reduction in ship numbers creates a specific challenge to this as the United States Navy is only supposed to procure 3 of these hulls, a full 29 hulls less than originally intended, which creates a large gap in planned procurement. In contrast, if you look at the DDG-51, it is a program that is still producing ships, and in large numbers needed. For significantly reduced spread cost, the United States Navy was able to purchase a significantly larger number of larger surface combatants, at a time when United States forward naval presences is needed and the country does not have the time to wait for systems to come online. There is one down draw to this approach though. The DDG-51, although a capable ship, that is available for deployments, does not have the requirements to be able to adapt to some of the future weapon system slated to come online in the naval domain. The DDG-51 flight III, which will not fully come online until 2023, will not be able to expand its design and useable space enough to fulfill all of the power requirements needed for all of the advanced systems. The United States Navy is moving forward on designing the Large Surface Combatant (LSC) with a evolutionary design and procurement concept.¹⁷⁰

¹⁶⁹ O'Rourke, Ronald. *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress* : Congressional Research Service, 2016.

¹⁷⁰ Trevithick, Joseph. "The Navy May Use One Hull Design to Replace its Cruisers and Destroyers." <http://www.thedrive.com/the-war-zone/22138/the-navy-may-use-one-hull-design-to-replace-its-cruisers-and-some-destroyers>.

The United States is facing a dilemma moving into the 21st century. The rules based global system that the U.S. created after World War Two is being challenge by both a resurgent Russia and an ever increasingly aggressive China. Beyond those two major geopolitical threats, the United States is also facing an increased threat from violent non-state actors such as Al-Qaeda and the Islamic State of Iraq and Syria (ISIS) to name a few. The United States Department of Defense will have to adapt to being able to build and procure weapons systems in a fashion that they can continue to maintain superiority in all realms of conflict. This paper examines one of the possible tools to accomplish that goal. The purpose of this argument and examination is not to direct or detract the Department of Defense innovation process or footing. Innovation is necessary and the technology provided by programs such as the F-22, F-35, and DDG-1000 are groundbreaking and necessary for securing and advancing our preeminence and domination in the security sphere. But these evolutions came at incredible cost and still leave the force short of the needed capabilities. These advances can be made in a cheaper and more effective way if the Department of Defense pursues a spiral development strategy coupled with evolutionary acquisition. The Pentagon needs to move from a cold war acquisition footing to a leaner, more agile program, which is needed to procure the tools, which will protect the United States far into the future. The Department of Defense, now more than ever, needs to use the defense dollar wisely and in a transparent manner. As exemplified above, taking large technical risks, while offering great increases in capabilities, also can serve to drain resources and time. This just serves to increase the burden on the existing forces and delays inevitable modernization and recapitalization, which will have to be done in the future, in a potentially tighter fiscal environment.

Making Sense of it All: How to Maintain the Edge?

The U.S. military and defense apparatus needs to approach acquisitions of systems in a new way. The doctrine and concepts behind the approaches are sound. Systems of systems have led to a complete technological overmatch on the battlefield, but these benefits come with risk. In the pursuit of new technologies, the Department of Defense has found itself in multiple situations where billions in investment has led to nothing. In this current fiscal and political environment, these mistakes can be fatal to programs and the department.

The military faced similar issues in the 1930s. The world was facing multiple threats, the global political situation was in turmoil and still recovering from the wake of the First World War, and a global depression had ravaged world economies. The U.S. Government needed to navigate through fiscal challenges, political angst, and competing ideologies about the nation's role in the world. The military, with the technology and assets it had, embarked on building up for a war that was all to clear on the horizon. The United States Navy was bridled by arms treaties up to the last minute, but because of a strong industrial base and adaptation of existing technologies. The United States Navy also benefited from the ingenuity of the American tactician and warfighter. Aircraft Carriers proved to be powerful weapons, but only when put in the right hands and used the correct way. The United States developed the PAC-10 carrier tactic that turned these modern day weapons into modern successes and a tool to project dominating U.S. power for years. Innovation, adaptability, and flexibility were the keys the United States Navy

used to propel itself into a dominant role in the world. The United States also had a strong industrial, political, and civilian sector to support the Services needs. This has not changed today, but the Department of Defense should consider the accomplishments that propelled it into the dominant position it holds today.

World War Two proved to play a strong role in incubating the aircraft carrier. As the need for ships and power projection in the Pacific grew ever stronger, the Navy worked a new concept for aircraft carriers and created one of the most powerful naval formations in history. This ingenuity is exactly what the Department needs.

Moving forward to the 21st century, the world has similar factors controlling political discourse. 2007 and 2008 saw a large global recession that the west is still struggling to recover. The global political order is at threat from multiple actors, and the United States is working through different fiscal and political constraints. The United States military and procurement in the Department of Defense is not immune to this. Although the problem is only worsened by the uncertainty coming from Congress in the form of the Budget Control Act, and uncertainty with appropriations, recent procurement strategies have caused trouble as well.

After the Cold War, the Department of Defense spent an immense amount of money to modernize and revolutionize United States forces, much of which was spurred by the pursuit of the “system of systems” vision for the military. This caused the loss of precious time and resources and has given space for our adversaries to catch up. The case of the Joint Tactical Radio System proves this as the United States saw heavy investment into a technology that did not provide the warfighter the capability they needed, but rather saw the Department of Defense rapidly look for a solution to fill an immediate

need. This example is not alone. The Department of Defense's past is littered with over budget and under producing defense projects that have put our forces at a loss. This study looks at just one of them, but projects like the Future Combat System, Airborne Laser, and the RAH-66 Comanche stealth helicopter are some other great examples of the Department pursuing needed replacements only to produce huge price tags and capability gaps. McKenzie Eaglen of the American Enterprise Institute believes these programs and other alone wasted \$75 billion dollars and left the United States facing \$370 billion in deferred modernization efforts. This will only serve to put more pressure on modernization and procurement budgets as the United States moves closer to the end of the life for many of its major tactical and strategic combat systems.¹⁷¹

The Department and Services should not give up on research and innovation, but there approach needs to be more conservative and risk mitigated. The cases of the F/A-18, F-22, DDG-1000, and DDG-51, while different systems fulfilling different requirements, paint a picture. Evolutionary acquisition and spiral development helps to bring systems online in the quantities needed to fulfill requirements. In a high risk world and facing competing priorities in the Department of Defense and more generally in federal spending, increased costs and delays in any project could make it vulnerable to cutting and reduction in scope.

The U.S. has also had success in this type of rapid, but evolutionary acquisition approach that contained risk and provided solutions to rapidly developing problem sets, proving that the military is capable of these changes at a smaller scale. Big Safari, an Air Force program that was used to modernize and update specialized airframes at a lower

¹⁷¹ Eaglen, Mackenzie. *Repair and Rebuild: Balancing New Military Spending for a Three-Theater Strategy*. Washington, DC: American Enterprise Institute, 2017.

cost to the taxpayer. Its unique management structure allows for quick and more efficient acquisition of systems at lower cost to the department. Because of this, the Air Force is able to adapt and modernize legacy airframes to meet current threats and respond to rapid need.¹⁷²

With a more conservative approach to acquisition, the U.S. could invest in proven systems and concepts and update them to meet the needs of the 21st century threat environment. This responsible spending profile would also allow the Department more leverage in negotiating and justifying budgets to Congress. Expensive programs that go over budget and off-schedule have created fatigue in funding ever-higher defense budgets. The more responsible program strategies would help to mend that trust. If this change does not happen, and quickly, the military could experience

The United States was able to harness naval aviation and build a strong and innovative strategy to incorporate these technologies into naval strategy. The United States was able to do this in part because of the strong industrial base, but also because of sound development of naval doctrine and incremental increasing of capabilities. The first two fast attack carriers began as cruisers, but had to be converted to meet treaty obligations. The U.S. Navy figured how to use this non-traditional technology, incrementally upgraded its capabilities, and introduced the fast attack carrier doctrine, all within a short time span. Targeted investment in proven and within reach technological advances turned out one of the most formidable naval formations in history, and secured the United States' position as the most capable and powerful military of the 20th century.

¹⁷² Pike, John. "Military." *Big SAFARI History*, Globalsecurity.org
https://fas.org/irp/program/collect/big_safari.htm

The United States needs to harness this ingenuity as it moves into the 21st century. Defense Budgets need to increase to meet the current requirements and needs of the 21st century, but the Department of Defense must use its resources wisely. The strategies of the past will inform the future. The Department of Defense needs to focus on acquisitions that are technically achievable as well. An issue that industry faces developing weaponry for the Defense Department is overburdening the process with requirements ending in unfeasible systems, such as the Joint Tactical Radio Systems' Ground Mobile Radio. The Joint Tactical Radio System was a technological achievement as it helped introduce the concept of software defined radios across a broad spectrum of military applications, but the program broke under its own weight and never fully fielded due to cost overruns and lack of useful technical achievements. Moreover, the U.S. military pursued a revolution in military affairs aggressively as the thinking was that a modernized and interconnected force would rule the 21st century. While the thought process and doctrine was sound, pushing the technological envelope to realize gain created political and fiscal issues that hamstrung modernization efforts.

Evolutionary acquisition and spiral development can prove cost effective and introduce new and needed technology while removing the risk from the procurement system. The F-22, F/A-18, DDG-1000 class ship, and DDG-51 class ship show that this can prove true. In this case the DDG-51 and F/A -18, which are legacy systems, have been upgraded to fight in the 21st century, and have proven successful in that transition. The cutting edge technology in the F-22 and DDG-1000 proved incredible capability, but cost overruns and technical challenges limited the system buys and the small quantities procured did not fulfill the intended requirement. This left the Department with a large

bill and still capability gaps to fill and systems to modernize and recapitalize. The Department must decide how to approach technology in the most cost effective manner. That means the Department needs to look at it developing new technologies or building and evolving on old system to adapt with new technology. Because newer technology failed to provide the numbers and quantities of systems needed to fulfill current requirements, the legacy forces are beginning to fatigue. Moving forward, this cannot happen. With the age of systems and fatigue on the force at a close to all time high, a refresh needs to happen and happen fast. But until risk is reduced from the process, money will not be used efficiently.

This is not to say that there is no place for revolutionary acquisition. As demonstrated by this study the U.S. Navy in World War Two and countless other examples throughout history, pushing the technological edge is a must to advance strategy and capability. Even in the case of the Joint Tactical Radio System, the F-22 and the DDG-1000, the programs may not have fully developed, but they did provide a new understanding of what technologies are needed in the future and how they can be attained and how they can be successfully operated. This study does not look at some of the other questions about the acquisition process either. By pursuing evolutionary and spiral processes, the Defense Department can successfully work within the confines of the current system. Another avenue all together, that would require much more political capital is how do we change the system to make it work better. The Congress is working to do this right now, but it is not a easy process. Looking at the factors that make requirements so burdensome and disconnect the cost and time estimate process are

important steps to realizing how the U.S. can make a more efficient system so that innovation is not stifled.

The Department of Defense and the Services will benefit from continuing to pursue strategies that provided the quantities and technology refreshes needed to meet the needs and requirements in the future. As in World War Two the U.S. needs to work within the constraints of the environment. In the case of World War Two, the U.S. had to work within the confines of the Washington Treaty and other iterations of arms agreements until the eve of the war, but was able to use previously built equipment and industrial capacity to invent and innovate strategy to bring the U.S. military into the powerful spot that it inhabits today. Moving forward to the 21st century, the U.S. military faces a similar situation. Budgets and politics harness unlimited research and procurement spending. The Department and Services will need to pursue a less risky acquisition and innovation strategy to field more proven technology. Instead of focusing on clean sheet brand new innovative designs, acquisition should be focused on bringing new innovative technologies on board proven systems. This evolution of technology will reduce risk in the procurement system and restore political trust in defense acquisition programs.

The Department of Defense has already embarked on this, with updating legacy systems, promoting open architecture, and pursuing cost effective upgrades with commercially available technology. There is still more to accomplish. This study shows some of the data driven arguments for pushing a more conservative and risk-controlled approach, but does not seek to be the end of the conversation. More study will be needed in the future to make sure that innovation is not stamped out in the name of risk

reduction, but the United States needs to pursue strategies that are stewards of the tax payer dollar to maintain the position that the institution currently maintains. The farther the United States moves into the future the more pressing this issue will become. The Department of Defense will continue to grapple with increasing modernization and procurement costs all while the fiscal situation becomes grimmer for the United States. Debt, deficits, and interest payments will continue to rise and threaten to crowd out investment in defense and non-defense spending alike.¹⁷³ By that time it will be too late to change course and rescue federal spending. Without changes to United States government spending deficits will remain large and investors may not be willing to take a risk on U.S. debt without larger interest rates, at that point, a significant portion of revenues will divert to servicing the debt and Department of Defense priorities, among many other government priorities will have to compete much more fiercely for resources.¹⁷⁴ The Department of Defense cannot fix those larger fiscal issues, but it can spend in a responsible fashion. This will allow for supporters in Congress and the public to continue to support spending.

Finally, in no ways is this piece arguing for the total elimination of revolutionary acquisition, but a reflection of the changing character of threats, budgets, and innovation. Commercial entities can now produce the leading edge technology that was once exclusive to the defense community. As we move into new domains of warfare this will continue to change. Silicon Valley and private industry are leading in innovation in the cyber world and space. The government does not have the flexibility to adapt at the speed of Moore's law. While the U.S. should continue to push the envelope in revolutionary

¹⁷³ Congressional Budget Office. *The Budget and Economic Outlook: 2018 to 2028*. Washington, DC: Congressional Budget Office, 2018.

¹⁷⁴ Ibid.

technologies and utilizations of new technology, the Department of Defense needs to leverage new technology in old systems to get the best effect. This will help to control costs and bring new technology online. A side effect of this could be the transfer of risk from the Department of Defense to the private sector, or at least a risk sharing profile.

Throughout history there have been many examples of countries and specific defense programs falling by the wayside because of misplaced investments and slow development of new technologies. The Department of Defense could face those challenges if not careful to maintain the trust of taxpayers and Congress. In this era of budget uncertainty and the impending bow wave of equipment modernization the threat is acute. The Department and Congress are already looking at ways to develop and implement new technologies and strategies to modernize in a cost effective fashion. The gears of government are slow and institutional inertia is hard to reverse, but without permanent change to these processes and procedures, the United States could go the way of the British at the eve of naval aviation when it comes to security in the 21st century.

Congress also has a role to play in this change as much of this will require legislative change. Congress is seeking this change and have been working at a much higher pace to affect change through legislation. Between fiscal year 2016 and 2018 NDAs Congress pass 247 major provisions, which represents a much higher rate than in the previous 10 NDAs.¹⁷⁵ Generally Congress is targeting how to make acquisitions more rapid, efficient, flexible to respond to the ever-changing threat environment, but

¹⁷⁵ Schwartz, Moshe and Heidi Peters. *Acquisition Reform in the FY2016-FY2018 National Defense Authorization Acts (NDAs)*. Washington, D.C: Congressional Research Service, 2018.

also to make government contracting and the Department of Defense a more inviting environment for newer and more cutting edge companies and sectors to work with.¹⁷⁶

If the Department of Defense and the United States are to continue into the 21st century with the qualitative dominance the country and its armed forces have come to have against its adversaries, defense spending will need to increase, but this increase needs to be invested more efficiently. The Department and the men and women in it have the ingenuity and talent to implement some of the ideas in this research. When risk is reduced in the system there will be on budget result and capability increases.

¹⁷⁶ Ibid.

Bibliography

- "55 Radio Address Announcing an Unlimited National Emergency. May 27, 1941." *American Reference Library - Primary Source Documents* (01/01, 2001): 1.
- DEFENSE ACQUISITIONS: Assessments of Selected Weapons Programs*: Government Accountability Office, 2017.
- "F/A-18E/F: Changing Roles." *Flight Global*, 20 January 1999, 1999.
- "Five Power Naval Treaty of 1922-1923." *Five Power Naval Treaty of 1922-1923* (01/11, 2009): 1.
- "New York Ship Building." *GlobalSecurity.org*. Accessed July 2017, 2017.
- "Operationalizing Joint Vision 2010[*]." *Airpower Journal* 12, no. 3 (Fall98, 1998): 102.
- Section 809 Panel Interim Report*. Washington, DC: Section 809 Panel, 2017.
- Select Acquisition Report (SAR) F/A-18E/F*: Defense Acquisition Management Information Retrieval (DAMIR), 2011.
- Selected Acquisition Report (SAR) F-22*: Defense Acquisition Management Information Retrieval (DAMIR), 2010.
- Selected Acquisition Report (SAR): DDG 1000 Zumwalt Class Destroyer (DDG 1000)*: Defense Acquisition Management Information Retrieval (DAMIR), 2015.
- Selected Acquisition Report (SAR): DDG 51 Arleigh Burke Class Guided Missile Destroyer (DDG 51)*: Defense Acquisition Management Information Retrieval, 2015.
- "Ship Building 1933-1945 - Franklin D. Roosevelt." *GlobalSecurity.Org* July 2017.
- "United States Navy Fact File: Destroyer DDG." United States Navy. Accessed 7/13/2016, 2016.
- "United States Navy Fact File: Hornet Strike Fighter." United States Navy. Accessed 06/10, 2016.
http://www.navy.mil/navydata/fact_display.asp?cid=1100&tid=1200&ct=1.
- Archambault, Matthew T. "A Revolution (in Military Affairs) in Iraq." *Infantry* 93, no. 4 (Jul, 2004): 12.

- Arena, Mark and Irv Buckstein et. al. *DoD and Commercial Advanced Waveform Developments and Programs with Multiple Nunn-McCurdy Breaches*: Rand Corporation, 2014.
- Arquilla, John. *Worst Enemy: The Reluctant Transformation of the American Military*. Chicago: Ivan R. Dee, 2008.
- Axe, David. *Failure to Communicate: Inside the Army's Doomed Quest for the 'Perfect' Radio*. Online: The Center for Public Integrity, 2014.
- Biass, Eric H. and Wesley Fox. "Baseline Aircraft on Steroids." *Armada International* 36, no. 4 (Aug, 2012): 22.
- Bloomberg News. "DoD Axes Ground Mobile Radio Portion of JTRS Program." *Defense Systems*, Oct 17, 2011, 2011.
- Bottelson, CDR Jay. "Requirements and Cost Stability: A Case Study of the F/A-18 Hornet Program." *Defense Acquisition Research Journal: A Publication of the Defense Acquisition University* (October 2011, 2011): 390-201.
- Brannen, Kate. "As JTRS Schedule Slip, Outside Radios Gain Ground with U.S. Army." *Spacenews*, October 4, 2010, 2010.
- Brewin, Bob. "Pentagon Shuttters Joint Tactical Radio System Program Office." *Nextgov*, August 1, 2012.
- Capaccio, Anthony. "The Navy's \$22 Billion Stealth Destroyer is Delayed again." *Bloomberg*, April 14, 2016, 2016, sec. Bloomberg Technology.
- Committee on Naval Affairs. House. *List of Combatant Ships Not Limited by Washington Treaty*, 1928.
- Congressional Budget Office. *The Budget and Economic Outlook: 2018 to 2028*. Washington, DC: Congressional Budget Office, 2018.
- Corman, Julianne, Kim Harris, David Levin, Jeffery Schulte, and Brittney Shanks. "Support for Defense and Military Spending." *Public Opinion Quarterly* 79, no. 1 (03/01, 2015): 166.
- Cox, Matthew. "Pentagon Tells Congress to Stop Buying Equipment it Doesn't Need." *Military.Com*, Jan 28, 2015, 2015, <http://www.military.com/daily-news/2015/01/28/pentagon-tells-congress-to-stop-buying-equipment-it-doesnt-need.html>.
- Cressman, Robert J. "Historic Fleets." *Naval History* 23, no. 1 (02, 2009): 12-13.

- Dacus, Chad L. "Improving Acquisition Outcomes through Simple System Technology Readiness Metrics." *Defense Acquisition Research Journal: A Publication of the Defense Acquisition University* 19, no. 4 (10, 2012): 444-461.
- Davis, Otto A., M. A. H. Dempster, and Aaron Wildavsky. "A Theory of Budgetary Process." *The American Political Science Review* 55, no. 3 (1966): 529.
- Defense Industry Daily staff. "Israel Announces F-16 Variant Upgrades." *Defense Industry Daily*, Sep 04 2015, 2015.
- Defense Industry Daily staff. "JTRS Program to Continue After Restructuring." *Defense Industry Daily*, July 28, 2006, 2006.
- Defense Industry Daily staff. "The U.S. Military's DTCS 'Netted Iridium' Program." *Defense Industry Daily* (2011).
- Department of Defense. "2018 National Defense Strategy: Sharpening the American Military's Competitive Edge." 2018.
- Desilver, Drew. "5 Facts about the National Debt." Pew Research 2018.
<http://www.pewresearch.org/fact-tank/2017/08/17/5-facts-about-the-national-debt-what-you-should-know/>.
- Dickstein, Corey. "Army: Increasing Combat Readiness More Important than Increasing Force Size." *Stars and Stripes*, June 7, 2017, 2017, sec. News.
- Dodge, Toby. "The Ideological Roots of Failure: The Application of Kinetic Neo-Liberalism to Iraq." *International Affairs* 86, no. 6 (11/01, 2010): 1269.
- Donnelly, Thomas. "They Only Say no." *The Weekly Standard*, May 29, 2015, 2015.
- Donnelly, Tom. "Why did Donald Rumsfeld Fail?" *Armed Forces Journal* 144, no. 6 (01/01, 2007): 34.
- Donovan, William J. *Vital Speeches of the Day* 6, no. 5 (12/15, 1939): 155.
- Drew, Christopher. "Obama Wins Crucial Senate Vote on F-22." *New York Times*, July, 21 2009, 2009, sec. Business Day.
- Duncan, Thomas K. 1. and Christopher J. 2. Coyne. "The Origins of the Permanent War Economy." *Independent Review* 18, no. 2 (Fall 2013, 2013): 219-240.
- Eaglan, Mackenzie. "Fixing the Fighter Gap Facing the U.S. Navy, Air Force, and Air National Guard." Heritage Foundation. Accessed 7/2016, 2016.

- Eaglen, Mackenzie. *Repair and Rebuild: Balancing New Military Spending for a Three-Theater Strategy*. Washington, DC: American Enterprise Institute, 2017.
- Eckerstein, Megan. "DDG-51 Program Office Preparing RFP for Next Multiyear Buy; Will Include Options for Additional Ships." *USNI News*, December 19, 2017, 2017, sec. Budget Industry.
- Eckstein, Megan. "New Requirements for DDG-1000 Focus on Surface Strike." 2018.
- Eide, Col Peter K. and Col Charles D. Allen. "The More Things Change, Acquisition Reform Remains the Same." *Defense Acquisition Research Journal: A Publication of the Defense Acquisition University* 19, no. 1 (01, 2012): 99-120.
- Elliott, Simon. "MDC Reveals New Hornet 2000 Details." *Flight International*, 12 September 1999, 1999, sec. Technical: Defense.
- Farkas, Kenneth and MAJ Paul Thurston (USAF). "Evolutionary Acquisition Strategies and Spiral Development Processes." *PM Magazine*, July-August 2002, 2003, 10-14.
- Fast, COL. William USA (Ret.). "Improving Defense Acquisition Decision Making." *Defense Acquisition University* (2010).
- Fearon, James D. "Counterfactuals and Hypothesis Testing in Political Science." *World Politics* 43, no. 2 (1991): 169-195.
- Feickert, Andrew. *The Joint Tactical Radio Systems (JTRS) and the Army's Future Combat System (FCS): Issues for Congress*. Washington, D.C.: Congressional Research Service, 2005.
- Fiedler, David M. "HF Combat Net Radio Lesson Learned again." *Army Communicator* 29, no. 4 (Winter2004, 2004): 32.
- Fiedler, David M. "HF Combat Net Radio Lesson Learned again." *Army Communicator* 29, no. 4 (Winter2004, 2004): 32.
- Fox, Dan and John C. Morris. "The Role of Accountability in Federal Acquisition: A Search for Context." *Journal of Public Procurement* 15, no. 4 (Winter2015, 2015): 514-536.
- Frank, Deborah. "A Theoretical Consideration of Acquisition Reform." *Acquisition Review Quarterly* (1997).
- Fridman, Ofer. "Revolutions in Military Affairs that did Not Occur: A Framework for Analysis." *Comparative Strategy* 35, no. 5 (10/01, 2016): 388.

- Frunzeti, Teodor. "Content and Dynamics of the Current Revolution in Military Affairs." *Strategic Impact* 49, no. 4 (12, 2013): 7-12.
- Gallagher, Sean. "How to Blow \$6 Billion on a Tech Project: Military's 15 Year Quest for the Perfect Radio is a Blueprint for Failing Big." *ARS Technica: Technology Lab*, 6/18/2012, 2012.
- Gallagher, Sean and Larry Loeb. "Shifting Frequencies: The Joint Tactical Radio System is a Key Element in DoD's Shift to Network-Centric Operations." *Defense Systems*, Mar 24, 2008.
- Gansler, Jacques S. and William Lucyshyn. *Eight Actions to Improve Defense Acquisition*. University of Maryland: IBM Center for the Business of Government, 2013.
- Gansler, Jacques, Lucyshyn, William and John Rigilano. *The Joint Tactical Radio System: Lessons Learned and the Way Forward*: University of Maryland, 2012.
- Government Accountability Office. *Defense Acquisitions: Resolving Development Risks in the Army's Networked Communications Capabilities is Key to Fielding Future Force*: Government Accountability Office, 2005.
- George, Alexander L. and Andrew Bennett. "Comparative Methods: Controlled Comparison and within Case Analysis." In *Case Studies and Theory Development in the Social Science*, 151-181. Cambridge, Mass.: MIT Press, 2005.
- Gertler, Jeremiah. *Air Force F-22 Fighter Program*: Congressional Research Service, 2013.
- Giangreco, Leigh. "Block III Super Hornet Upgrades to Begin this Spring." *Flight Global*, 22 December 2017, 2017.
- GlobalSecurity.org. "Shipbuilding 1933-1945." Accessed July, 23, 2017.
- Gongora, Thierry and Harald von Riekhoff, eds. *Toward A Revolution in Military Affairs*. 1st ed. Westport, CT: Greenwood Press, 2000.
- Gould, Joe. "Lawmakers: Give US Navy More F/A-18s." *Defensenews*, March 2, 2016, 2016.
- Government Accountability Office. *TACTICAL AIRCRAFT: Comparison of F-22A and Legacy Fighter Modernization Programs*. Washington, D.C.: Government Accountability Office, 2012.

- Graffin, Scott D., Jerayr (John) Haleblian, and Jason T. Kiley. "Ready, Aim, Acquire: Impression Offsetting and Acquisitions." *Academy of Management Journal* 59, no. 1 (02/01, 2016): 232.
- Grimes, Steven R. *PPBS to PPBE: A Process Or Principles?*. Army War College, Carlisle Barracks: Defense Technical Information Center, 2008.
- Grove, Jairus. "An Insurgency of Things: Foray into the World of Improvised Explosive Devices." *International Political Sociology* 10, no. 4 (12/01, 2016): 332.
- Haney, Adm Cecil D. "Strategic Deterrence for the Future." *Air & Space Power Journal* 29, no. 4 (Jul, 2015): 4-8.
- Haney, Adm Cecil D. "Strategic Deterrence for the Future." *Air & Space Power Journal* 29, no. 4 (Jul, 2015): 4-8.
- Harrison, Todd. "The Effects of Competition on Defense Acquisitions." 2012.
- Hart, Gary. "An Agenda for More Military Reform." *The New York Times*, May 13, 1896, 1986.
- Heinrich, Thomas B. "Jack of all Trades: Cramp Shipbuilding, Mixed Production, and the Limits of Flexible Specialization in American Warship Construction, 1940-1945." *Enterprise & Society (Oxford University Press / USA)* 11, no. 2 (06/01, 2010): 275.
- Hone, Thomas. "Replacing Battleships with Aircraft Carriers in the Pacific in World War Two." *Naval War College Review* (2013).
- Hone, Thomas C. and Mark D. Mandeles. "Interwar Innovation in Three Navies: U.S. Navy, Royal Navy, Imperial Japanese Navy." *Naval War College Review* 40, no. 2 (03/01, 1987): 63.
- Hone, Trent. "U.S. Navy Surface Battle Doctrine and Victory in the Pacific." *Naval War College Review* 62, no. 1 (Winter2009, 2009): 67-105.
- Huntington Ingalls. "NNS and the American Aircraft Carrier." . Accessed August 2017, 2017.
- Jones D., Bryan, Laszio Zalanyi, and Peter Erdi. "An Integrated Theory of Budgetary Politics and some Empirical Tests: The U.S. National Budget, 1791-2010." *American Journal of Political Science* 58, no. 3 (2014).
- Jury, Matthew A. "Matt". "Reuse, Refine, Resolve." *Army AL&T Magazine* (Jan, 2017): 92-95.

- Kaen, Fred R. "World War II Prime Defence Contractors: Were they Favoured?" *Business History* 53, no. 7 (12, 2011): 1044-1073.
- Kaplan, Fred. "Procuring Innovation." *MIT Technology Review* 120, no. 1 (01/01, 2017): 64.
- Kem, Jack D. "Military Transformation: Ends, Ways, and Means." *Air & Space Power Journal* 20, no. 3 (09/01, 2006): 85.
- Kendall, Frank. "DoD use of Commercial Acquisition Practices." *Defense AT&L* 44, no. 5 (Sep, 2015): 2.
- Kendall, Frank. "Real Acquisition Reform (Or Improvement) must Come from within." *Defense AT&L* 45, no. 3 (05/01, 2016): 2.
- Klein, Maury. *A Call to Arms: Mobilizing America for World War II*. First US ed. New York: Bloomsbury Press, 2013.
- Knox, James M. "Private Enterprise in Shipbuilding." *Harvard Business Review* 24, no. 1 (09/01, 1945): 75.
- Kotter, John P. "Leading Change: Why Transition Efforts Fail." *Harvard Business Review* (1995).
- Kreisher, Otto. "Marines Taking 30 Hornets from Bone yard, Navy Inventory to Address Readiness Crisis." *United States Naval Institute News*, June 23, 2016, 2016, sec. Aviation.
- Subcommittee on Sea power and Expeditionary Forces. *The Navy's Surface Combatant Programs*. 1st Session 110th Congress sess., 2008.
- LaGrone, Sam. "Navy Requires \$450 Million More to Complete Zumwalt-Class due to Shipyard Performance." *United States Naval Institute News*, April 6, 2016, 2016.
- LaGrone, Sam. "Navy's Planned 80 Super Hornet Buy could Grow After New Pentagon Strategy Review." *United States Naval Institute News*, June 15, 2017, 2017.
- LaGrone, Sam. "Two Billion Dollar DDG-1000 Cost Growth Explained." *United States Naval Institute News* (May 27, 2014, 2014).
- Lawlor, Maryann. "Marines Build a Transformational Bridge." *Signal* (20014).
- Logel, Jon Scott. "Playing War: War-gaming and U.S. Navy Preparations for World War II." *Naval War College Review* 69, no. 3 (07/01, 2016): 152.

- Lorenz, Edward. "Work Organization Conventions and the Declining Competitiveness of the British Shipbuilding Industry, 1930-1970." *Historical Social Research / Historische Sozialforschung* 40, no. 1 (2015): 112-131.
- Lovelace, Douglas. "the Evolution in Military Affairs: Shaping the Future U.S. Armed Forces " *Strategic Studies Institute* (1997).
- Majumdar, Dave. "US Navy's Sixth-Generation F/A-XX Fighter: Just a 'Super' Super Hornet?" *The National Interest*, July 26, 2016, 2016, sec. The Buzz.
- Manthorpe, William. "The Emerging Joint System of Systems: A Systems Engineering Challenge and Opportunity for APL." *Johns Hopkins APL Technical Digest* 17, no. 3 (1996): March 10, 2017.
- McCain, John. "Restoring American Power: Recommendation for the 2018-2022 Defense Budget" https://www.mccain.senate.gov/public/_cache/files/25bff0ec-481e-466a-843f-68ba5619e6d8/restoring-american-power-7.pdf.
- Misinec, Marcus. "Bleeding Talent: How the U.S. Military Mismanages Great Leaders and Why it's Time for a Revolution." *Army Lawyer* (02/01, 2014): 34.
- Mountcastle, Clay. "The Myth of the New Complexity." *Military Review* 96, no. 2 (Mar, 2016): 47.
- Naval History and Heritage Command, Communications and Heritage Command. "As War in Europe Escalated, 1940 Expansion Act Came when Platforms Mattered most." *The Sextant* (July 19, 2014, 2014).
- O'Rourke, Ronald.
Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress : Congressional Research Service, 2016.
- O'Rourke, Ronald. *Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress*: Congressional Research Service, 2016.
- Owens, ADM William. "The Emerging U.S. System-of-Systems." *Strategic Forum: Institute for National Strategic Studies* 63, (1996).
- Peck, Michael. "Why is America Wasting the F-22 Raptor on Bombing ISIS?" *The National Interest*, October 1, 2014, 2014.
- Pelczynski, COL Anthony S. "Rapid Acquisition Impact on Major Defense Acquisition Programs." Masters of Strategic Studies, United States Army War College, 2010.

- Pike, John. "Military." *Big SAFARI History*, Globalsecurity.org
www.globalsecurity.org/military/systems/aircraft/f-22-history.htm.
- Prezelj, Iztok, Erik Kopac, Aleš Žiberna, Anja Kolak, and Anton Grizold. "Evolutionary Reality of the Revolution in Military Affairs: Results of a Comparative Study." *Romanian Journal of Political Science* 15, no. 2 (Winter2015, 2015): 4-34.
- Rodrigues, Louis J. *Navy Aviation: The F/A-18E/F Will Provide Marginal Operational Improvement at High Cost*. Washington, D.C.: Government Accountability Office, 1996.
- Rogoway, Tyler. "Stealthy F-15 Silent Eagle may Get a Reprieve as Israel Requests More Eagles." . Accessed July 24, 2016. <http://foxtrotalpha.jalopnik.com/f-15-silent-eagle-may-get-a-reprieve-as-israel-requests-1740179374>.
- Rosenberg, Barry. "From Radios to Waveforms: How JTRS is Making itself as JTNC." *Defense Systems*, September 06, 2012, 2012.
- Rubel, Robert C. "The Future of Aircraft Carriers." *Naval War College Review* 64, no. 4 (09, 2011): 12-27.
- Rumsfeld, Donald H. "Transforming the Military." *Foreign Affairs* 81, no. 3 (05/01, 2002): 20.
- Rumsfeld, Donald and Donald Rumsfeld. "Lessons Learned." *Presidents & Prime Ministers* 12, no. 2 (Mar, 2003): 24.
- Russell, Cary B. and United States. *Counter-Improvised Explosive Devices*. Washington, DC: U.S. Govt. Accountability Office, 2012.
- Schwartz, Moshe and Heidi Peters. *Acquisition Reform in the FY2016-FY2018 National Defense Authorization Acts (NDAA's)*. Washington, D.C: Congressional Research Service, 2018.
- Serbu, Jared. "DoD Brings Culture of Open Architecture to a World of Proprietary Systems." *Federal News Radio*, November 13, 2013, 2013.
- Shachtman, Noah. "How Technology almost Lost the War: In Iraq the Critical Networks are Social- Not Electronic." *Wired Magazine*, 11.27.07, 2007.
- Shoemate, Will and Benjamin Jensen. "Training for Decisive Action." *Military Review* 96, no. 5 (Sep, 2016).
- TACTICAL AIRCRAFT: Concurrency in Development and Production of the F-22 should be Reduced*: Government Accountability Office, 1995.

- Talbot, David. "How Technology Failed in Iraq." *MIT Technology Review* (2004).
- Trevithick, Joseph. "The Navy may use One Hull Design to Replace its Cruisers and Destroyers." . <http://www.thedrive.com/the-war-zone/22138/the-navy-may-use-one-hull-design-to-replace-its-cruisers-and-some-destroyers>.
- The Joint Chiefs of Staff. *The Joint Vision 2010*, edited by Shalikashvili, John U.S. Department of Defense, 2000.
- The Obama Administration. "The National Security Strategy: 2015."
- The White House. "National Security of the United States of America.: 2017"
- The World Bank. "Military Expenditure (% of Central Government Expenditures)." The World Bank.
https://data.worldbank.org/indicator/MS.MIL.XPND.ZS?locations=US&name_desc=true.
- Tillman, Barrett. "The Carrier Comes of Age." *Naval History* 24, no. 5 (10, 2010): 22.
- Tillman, Barrett. "Forging the Weapon." *Naval History* 24, no. 5 (10/01, 2010): 14.
- "Understanding Military Culture." Department of Veterans Affairs. https://www.mentalhealth.va.gov/communityproviders/military_culture.asp.
- Underwood, Annalisa. "Evolution of the Aircraft Carrier." Naval History and Heritage Command, Communication and Outreach Division. Accessed August 2017, 217.
- Weisgerber, Marcus. "F-35 is 'Ready for War;' Now the Air Force Wants More, and Faster." *Defenseone*, August 2, 2016, 2016.
- Whaley P, Eileen and Dana Stewart. "Path from Urgent Operational Need to Program of Record." *Defense Acquisition Reform Journal* 21, no. 2 (2014): 526.
- Williams, Shara, Jeffrey A. Drezner, Megan McKernan, Douglas Shontz, and Jerry M. Sollinger. *Rapid Acquisition of Army Command and Control Systems*. Washington DC: Rand Corporation, 2014.
- Wilson, J. R. "Robotic Technologies for the Future Land Warrior." *Military & Aerospace Electronics* 27, no. 6 (06/01, 2016): 8.
- Wirks, Daniel. "Congress and the Politics of Military Reform." *Armed Forces & Society* (0095327X) 17, no. 4 (1991): 487-512.

Younossi, Obaid, David Stem, Mark Lorell, and Frances Lussier. *Lessons Learned from the F/A-22 and F/A-18E/F Development Programs*, Santa Monica, CA: RAND Corporation, 2005.

Zweibelson, Ben. "One Piece at a Time: Why Linear Planning and Institutionalisms Promote Military Campaign Failures." *Defence Studies* 15, no. 4 (12/01, 2015): 360.

Curriculum Vitae

Charles Carroll was born in Evanston, Illinois on June 19, 1990. He attended Dickinson College in Carlisle, Pennsylvania and graduated in 2013 with his Bachelor of Arts in Middle East Studies and a minor in Arabic. He is married and lives in Washington, DC as of publication.